



Amputation för kärlsjukdom

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AMPUTATION FÖR KÄRLSJUKDOM

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INLEDNING

Amputation för kärlsjukdom på nedre extremiteten har ökat dramatiskt i Sverige (Hansson 1964, Hierton och James 1973), liksom i övriga västvärlden (Kay och Newman 1975, Berardi och Keonin 1978, Vitali et al 1978). Patienter med underbensgangrän fordrar allt större sjukvårdsresurser. Patienter med gangrän konsumerade 1977 5,0 % och 1980 8,4 % av de 30.000 vårddagarna vid ortopediska kliniken i Lund. Gangränpatienterna krävde 1979 6.000 vård dagar i slutet somatisk korttidsvård i Malmöhus läns landstingsområde med en halv miljon invånare.

Amputation för kärlsjukdom på nedre extremiteten har blivit ett vanligt ingrepp medan sådan amputation på övre extremiteten är sällsynt. I Malmöhus län benamputerades 161 patienter under 1979. Medelåldern för dessa patienter var 76 år. För att kunna bedöma behovet av fortsatt vård och rehabilitering behövs ökad kunskap om förloppet efter amputation.

En undersökning har därför genomförts dels av den befolkningsrelaterade förekomsten av amputation i Malmöhus län och dels av några tänkbara orsaksfaktorer. Därvid studerades faktorerna hög ålder, diabetes och rökning bland de nyamputerade.

Rehabilitering efter amputation på lårbensnivå är sämre än på underbensnivå (Stirnemann 1978). Val av amputationsnivå och läkning efter amputation är viktiga för rehabilitering och protesförsörjning (Davis et al 1967, Romano & Burgess 1971, Jensen et al 1982A). Amputationsstumpens form och egenskaper är viktiga för protesfunktion och social

rehabilitering. Förmågan att belasta stumpändan kan ha betydelse för utformningen av den definitiva protesens. Dessa faktorer har studerats systematiskt. Tidig gångträning är viktig som prevention mot liggsår och kontraktur (Kerstein 1974, Devas 1977) men omedelbar protesförsörjning (Berlemont 1961) har hos dem som amputerats för kärlsjukdom gett upphov till läkningskomplikationer (Mooney 1971, Cohen et al 1974). Förmågan att tåla tidig belastning i träningsprotes har undersökts för att bedöma möjligheten av att påskynda rehabiliteringsförloppet och aktivera patienten.

Efter amputation har förloppet studerats avseende patienternas sociala rehabilitering. Påverkan på ADL-funktionen är måttlig efter amputation (Renström 1981) men avgör om patienten kan återvända hem (Kohn 1965). Undersökningen avser att försöka finna förebyggande åtgärder mot amputation och kompenserande åtgärder efter amputation. Härvid har bostadssituation, gångförmåga och ADL-status före och efter amputationen studerats av ett särskilt rehabiliteringsteam bestående av arbetsterapeut, kurator, ortopedläkare, sekreterare och sjukgymnast. Detta team har följt patienterna även genom hembesök ett år efter amputationen. På en särskild veckomottagning för protespatienter med ortopedtekniker och ortoped har stumpproblem och protesproblem bedömts. Murdock (1977) framhåller att teamarbete är mycket betydelsefullt för ett gott behandlingsresultat och denna sammanfattning är skriven på svenska för att vara lättare tillgänglig för alla dem som engageras av dessa patienters återanpassning och eftervård.

Syftet med undersökningen har varit att belysa följande problemställningar:

- 1 Hur vanlig är amputation för kärlsjukdom och vilka faktorer ökar risken för amputation?
- 2 Vilka egenskaper har amputationsstumpar och hur tolereras tidig protesträning med totalkontakthylsa?
- 3 Hur påverkas rehabiliteringen av sociala och medicinska faktorer?

AVHANDLINGEN BASERAS PÅ FÖLJANDE ARTIKLAR

- I Liedberg, E., Persson, B.M. Increased incidence of lower limb amputation for arterial occlusive disease. (Accepterad för publikation i Acta Orthop. Scand.)
- II Liedberg, E., Persson, B.M. Age, diabetes and smoking in lower limb amputation for arterial occlusive disease. (Accepterad för publikation i Acta Orthop. Scand.)
- III Persson, B.M., Liedberg, E. A clinical standard of stump measurement and classification in lower limb amputees. (Accepterad för publikation i Prosthetics and Orthotics International).
- IV Persson, B.M., Liedberg, E. Measurement of maximal end-weight-bearing in lower limb amputees. (Accepterad för publikation i Prosthetics and Orthotics International).
- V Liedberg, E., Hommerberg, H., Persson, B.M. The tolerance of early walking with total contact among below-knee amputees - A randomized test. (Att publiceras).
- VI Liedberg, E., Andersson, L., Rosén, B. Sociomedical history and prediction of rehabilitation following amputation for arterial occlusive disease. (Att publiceras).

I texten hänvisas till artiklarna med romerska siffrorna I-VI.

ÖKAD INCIDENS AV AMPUTATION PÅ NEDRE EXTREMITETEN FÖR KÄRLSJKDOM (ARTIKEL I)

INTRODUKTION

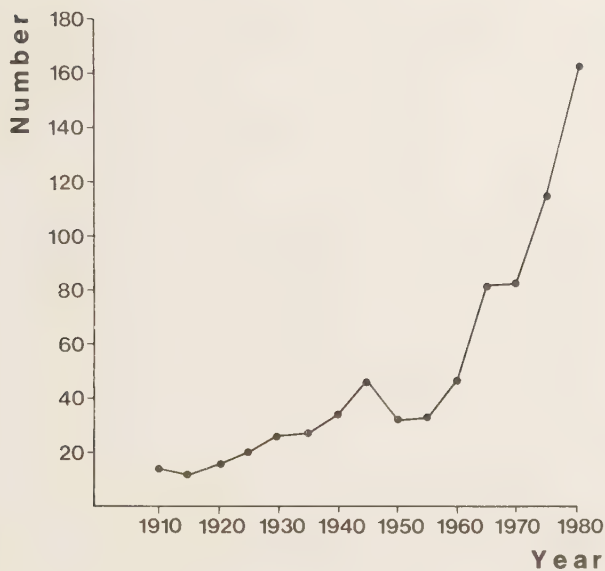
I Skandinavien liksom i västvärlden i övrigt ökar antalet amputationer för kärlsjukdom (Hansson 1964, Lindholm 1964, Hierton och James 1973, Vitali et al 1978). Sjukhusvård för perifer kärlsjukdom och kärlkirurgi ökar samtidigt (Tibell 1971, Eickhoff 1981). Antalet amputationer för kärlsjukdom inom en känd befolkning har därför studerats under en längre tidsperiod (1910-1979) och omfattar således både medicinska framsteg och förändringar i populationen.

MATERIAL OCH METOD

Malmöhus läns landstingsområde har studerats avseende förekomsten av amputation för kärlsjukdom. Från 1970 har sjukvårdens dataredovisning använts. Före 1970 har antalet amputationer hämtats från de årliga verksamhetsberättelserna från sjukhusen i området. Avseende förekomsten av diabetes har patientjournalerna från 1979 studerats. Patienten har bedömts som diabetiker om tablett eller insulinbehandling behövts.

RESULTAT

Antalet amputationer för kärlsjukdom hade ökat omkring 10 gånger från 1910 till 1979 och omkring 5 gånger från 1950 (Figur I:1). År 1979 var 74 % av de amputerade över 70 år, 54 % var män och 37 % hade diabetes. Med utgångspunkt från antalet amputationer i olika åldersgrupper 1979 bestämdes den åldersrelaterade amputationsincidensen (Tabell I:1). Den årliga incidensen i populationen 60 år eller mer var 1,4 per tusen invånare. Incidensen i befolkningen som helhet var 0,3 per tusen invånare.

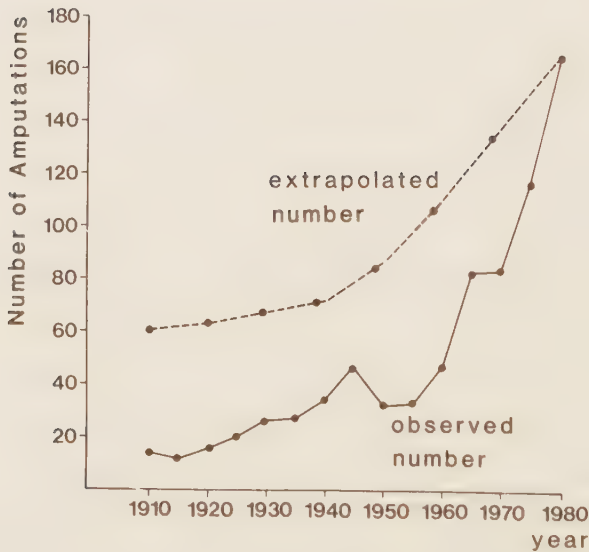


Figur I:1 Antalet amputationer för kärlsjukdom 1910-1979.

Tabell I:1 Incidens, ålder, kön och diabetes hos amputerade i landstingsområdet 1979.

Åldersgrupp	Antal invånare	Antal amputerade	Andel män	Andel diabetiker	Incidens per tusen
-39	290.800	-	-	-	-
40-59	112.900	11	.45	.64	.1
60-69	50.300	31	.65	.39	.6
70-79	38.000	58	.50	.34	1.5
80-	16.100	61	.54	.34	3.8
Totalt	508.100	161	.54	.37	.32

Det antal amputationer som teoretiskt skulle ha inträffat om den åldersrelaterade incidensen hade varit densamma under de sista 70 åren har beräknats. Användningen av de åldersrelaterade incidenserna från 1979 gav en teoretisk kurva (Figur I:2). Det faktiska antalet amputationer har ökat mer än 10 gånger och populationen 60 år eller mer 4 gånger. Detta innebär att det skett en fyrfaldig ökning från 1910 till 1979 efter korrektion för det ökade antalet äldre i befolkningen. Andra orsaker bör således sökas som förklaring till den fyrfaldiga ökningen.



Figur I:2 Förväntat antal amputationer under perioden 1910-1979 om incidensen varit konstant. 1910 utfördes 14 amputationer mot beräknat 61.

ÅLDER, DIABETES OCH RÖKNING VID AMPUTATION FÖR KÄRLSJKDOM PÅ NEDRE EXTREMITETEN (ARTIKEL II)

INTRODUKTION

Det ökande antalet åldringar i befolkningen och den ökade överlevnaden hos patienter med diabetes förklarar inte ökningen i antalet amputationer. Att rökning kan vara en bidragande faktor är ofta nämnt (Sacket et al 1968, Auerbach et al 1968), men studier som värderar rökvanorna hos dessa patienter verkar ej ha publicerats. Bürger's sjukdom hos cigarettrökare som är en inflammatorisk kärlsjukdom utgör bara en liten del av antalet amputerade och börjar vanligen hos män som är yngre än 35 år. Denna studie är gjord för att analysera rökningens betydelse hos patienter som amputerats pga kärlsjukdom, dels för att bedöma rökningens betydelse för grav kärlsjukdom, dels för att kunna tala om för patienter med kärlsjukdom om det lönar sig att sluta röka.

MATERIAL OCH METOD

De 188 patienterna som amputerats för kärlsjukdom studerades avseende ålder, förekomst av diabetes och rökning. Patienterna bedömdes ha diabetes om medikamentell behandling gavs. Rökningssvanorna klassificerades i fyra grupper: icke-rökare, ex-rökare om de slutat mer än ett år före amputationen, måttlighetsrökare (mindre än 10 cigaretter om dagen) resp storrökare (mer än 10 cigaretter eller 10 gram tobak per dag).

Ett kontrollmaterial med identisk ålders- och könsuppbyggnad insamlades från befolkningsregistret.

RESULTAT

Av 188 amputerade var 100 män. Ättiofem hade aldrig rökst och 61 hade diabetes. Av 100 män hade 75 varit rökare, 29 hade diabetes och 38 var minst 80 år. Av 88 kvinnor hade tio varit rökare, 32 hade diabetes och 46 var minst 80 år. Av 188 amputerade fanns bara 23 som varken var rökare, diabetiker eller minst 80. I 12 av dessa fall var amputationsorsaken emboli-sjukdom, dvs central mer än perifer kärlsjukdom. (Fig II:1-2).

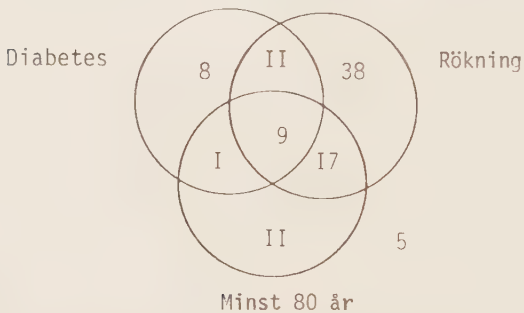


Fig II:1. Ålder, diabetes och rökning hos 100 män.

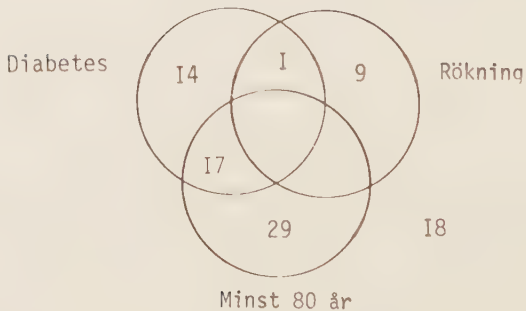


Fig II:2. Ålder, diabetes och rökning hos 88 kvinnor.

Då såväl diabetes som rökning kan bidra till utvecklingen av kärlsjukdom testades varje faktor för sig. Jämfört med kontrollmaterialet var rökare överrepresenterade bland män ($p < 0.002$) men ej bland kvinnor.

Rökning påverkade också åldern vid amputation. Ökande rökning sänkte åldern vid amputation hos män ($p < 0.001$) och hos kvinnor ($p < 0.001$) (Tabell II:1-2).

Tabell II:1 Ålder vid amputation och rökvanor hos män utan diabetes.

Rökvana	Antal	Medelålder	Spridning
Rökfria	16	80.9	54-91
Ex-rökare	18	76.9	64-84
Måttlighetsrökare	20	77.2	62-94
Storrökare	17	67.6	46-89

Tabell II:2 Ålder vid amputation och rökvanor hos kvinnor utan diabetes.

Rökvana	Antal	Medelålder	Spridning
Rökfria	47	82.9	69-98
Ex rökare	5	69.4	66-79
Måttlighetsrökare			
Storrökare	4	57.0	48-71

Diabetes påverkan på amputationsåldern studerades genom att alla rökare uteslöts ur jämförelsen. Medelåldern vid amputation hos män utan diabetes var 81 år, medan den var 72 hos diabetiker. Medelåldern hos kvinnor utan diabetes var 83 år och hos kvinnor med diabetes 78 år.

Den ålderssänkande effekten av diabetes var således 5-9 år vilket kan jämföras med rökningen där dessa åldersskillnader var 4-26 år beroende på kön och graden av rökning.

(Tab II: 1-2).

DISKUSSION OM FÖREKOMST OCH ORSAKSAKTORER

Antalet amputationer i Malmöhus län hade femfaldigats från 1950 till 1979 medan befolkningen över 70 år knappt trefaldigats. Denna stora ökning av amputation för kärlsjukdom stöds av liknande trender i andra befolkningsområden (Hansson 1964, Hierton och James 1973, Vitali 1978, Jernberger och Tryggö 1982) men incidensanalyser är fåtaliga. I Danmark var incidensen 0.13/1000 (Christensen 1976) men utan synbar ökning mellan åren 1961 och 1971. Jämförlig incidens var 1960 i Malmöhus län 0.12, 1970 0.17 och 1979 0.3. I Köpenhamn var incidensen hos befolkningen över 40 år under åren 1971-1979 (Mandrup-Poulsen och Jensen 1982) 0.3/1000 medan samma incidens i Malmöhus län 1975 var 0.5. Skillnaden i olika områden kan bero på befolkningsprofilerna. Incidensen i Malmöhus län var 0.1/1000 i åldersgruppen 40-59 år successivt ökande till 3.8/1000 i åldersgruppen 80 år och däröver. Medelåldern hos de amputerade har stigit liksom andelen över 80 år, nu mer än 1/3 i Malmöhus län. Renström (1981) redovisade för Göteborg drygt 1/4 medan studier från 1960-talet visar 10-20 % i denna åldersgrupp (Hansson 1964, Christensen 1976). För perioden 1971 till 1979 var motsvarande andel i Köpenhamn ca 1/4 (Mandrup-Poulsen och Jensen 1982).

Även med korrektion för det ökade antalet äldre i befolkningen hade således incidensen ökat fyra gånger från 1910 till 1979 i Malmöhus län.

En tänkbar och lätt identifierbar orsak bakom ökningen skulle kunna vara diabetes mellitus. Andelen diabetiker borde ha stigit med det stora antalet diabetiker som nu stått på behandling i många år men så har alls ej blivit fallet delvis därför att dödligheten är ökad hos diabetiker jämfört med befolkningen i övrigt (Garcia et al 1974). I denna undersökning var 1979 endast 37 % av de amputerade

diabetiker. Hansson (1964) redovisade hälften diabetiker och Hierton och James (1973) drygt hälften, medan Warren och Kihn (1968) i USA hade 39 %. I Köpenhamn 1971-1979 var diabetikerandelen 25 % (Mandrup- Poulsen och Jensen 1982). Andra faktorer än diabetes ligger alltså bakom huvuddelen av ökningen.

Efter diabetes nämns rökning i den allmänna debatten som en orsak till kärlsjukdom (Sacket et al 1968, Auerbach et al 1968) men i amputationsmaterial har denna faktor ej tidigare närmare analyserats. I denna undersökning studerades förekomsten av rökare bland de amputerade och jämförelse med en ålders- och könsmatchad kontrollgrupp ur befolkningsregistret utvisade samband. Avgränsningen mot det tidigare kända tillståndet - Bürger's sjukdom, en inflammatorisk kärlsjukdom hos yngre cigarettrökande män (McKusick et al 1962) är inte självklar, men i denna undersökning var endast två män som rökte under 50 år. I asiatiska länder där trauma orsakar mer än hälften av benamputationerna är diabetes och Bürger's sjukdom (trombangitis obliterans) mycket vanligare än arterioskleros (Kakurai och Sawamura 1982). Av praktiskt värde på kort sikt är att försöka förmå en rökare som amputerats att sluta röka. I denna studie var nämligen ex-rökare ej överrepresenterade bland de amputerade och i kärlkirurgiska material har det visats att de som fortsatte att röka hade avsevärt sämre resultat än de som slutade.

Genom att införa rutinen att notera förekomst av rökning lika systematiskt som förekomsten av diabetes ökar man möjligheten att kanske förbättra postoperativ läkning och minska risken för ytterligare amputationer på samma eller motsatta sidan.

Risken att bli amputerad pga kärlsjukdom om man är under 80 år, icke diabetiker och aldrig har rökt är obetydlig. Unga kvinnor röker nu mer än unga män vilket indikerar

en ökad andel kvinnor bland amputerade i framtiden (Barrol och Ramström 1980). Under de närmaste decennierna kommer antalet som är över 65 år att minska i befolkningen medan de som är över 80 år kommer att öka kraftigt. Detta gör det troligt att andelen amputerade över 80 år kommer att öka ytterligare med tilltagande krav på vårdresurser.

EN KLINISK STANDARD FÖR STUMPMÄTNING OCH KLASSIFIKATION HOS BENAMPUTERADE (ARTIKEL III)

INTRODUKTION

Amputationsstumparnas egenskaper är föga diskuterade i litteraturen trots att dessa är viktiga för funktionen med protes. Det ökade antalet amputationer för kärlsjukdom hos äldre ökar behovet av en objektiv stumpvärdering, därför att gamla patienter har svårare både att förstå och lämna information. För att välja ut och systematisera de basala kliniska parametrarna har olika alternativ för stumpkaraktäristik diskuterats. Vid ett möte med International Society of Prosthetics and Orthotics (ISPO) i Bologna 1980 ägnades en speciell konferens åt detta och vårt förslag modifierades och accepterades för användning. Med denna systematiska bedömning kan viktiga egenskaper hos stumpen identifieras och möjligheterna att förbättra dålig funktion ökas. Förarbetet och formulärets användning i en konsekutiv patientserie redovisas för att visa hur olika stumpegenskaper fördelas.

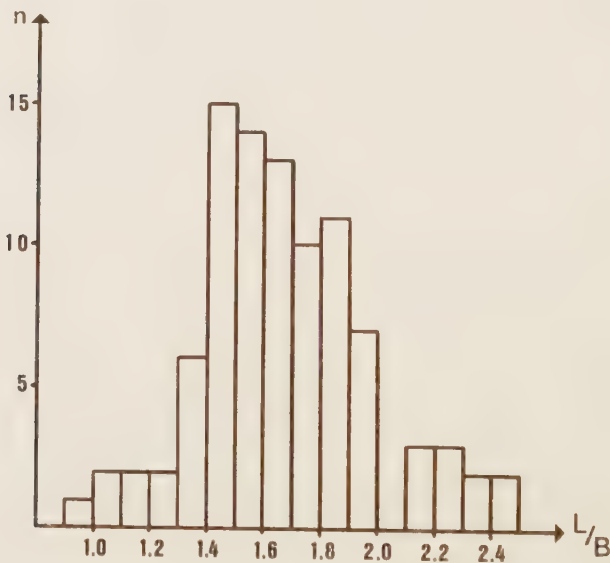
MATERIAL OCH METODER

I en konsekutiv serie av 93 underbensstumpar gjordes upprepade mätningar på underbensstumpar under de första 12 veckorna efter amputationen för att beskriva former och följa förändringar. Alla var amputerade med sagittal teknik (Persson 1974). Mätningar gjordes vid 2, 3, 4, 6 och 12 veckor avseende proximalt stumpomfång med knäet i 60° flexion, distalt stumpomfång och stumplängd från stumpens distala mjukdelsände till mediala ledspringan. Det vid ISPO:s möte accepterade formuläret (Fig III:1) användes sedan i en konsekutiv serie patienter vid ortopediska klinikens specialmottagning för amputerade. Sammanlagt gjordes 135 mätningar på 86 patienter med 96 amputationsstumpar. Tolv var lårbensamputerade och sju var ampu-

terade genom höft, knä eller fotled, medan 116 var på underbensnivå. Klassifikation gjordes avseende patientens allmänkondition och orsak till amputation, stumpens storlek, form, ärr, hud, mjukdelsförhållande, stumpända, rörlighet i proximal led och smärta. Slutligen angavs om protes-teknisk eller kirurgisk korrektion var indicerad.

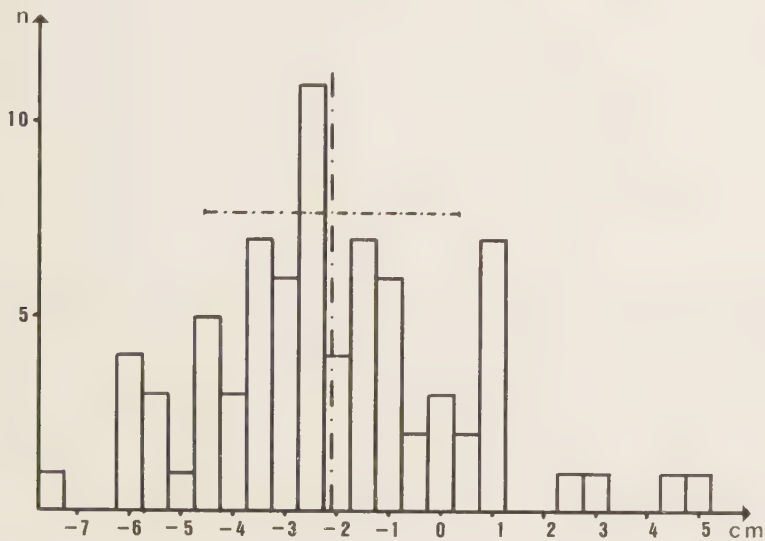
RESULTAT

Medianlängden var 16 cm (R 10-25) hos 93 underbensstumpar. Det proximala omfånget omräknades till diameter och användes vid uträkning av längd-bredd proportion (Fig III:2). Medelkvoten var 1,7 (R 0.9-2.5). En stump klassificerades som kort och 10 som långa.



Figur III:2. Kvoten mellan längd och bredd hos underbensstumpar.

Det distala omfånget minskade omkring 1,5 cm mellan 2 och 3 veckor och omkring 2 cm mellan 2 och 12 veckor. Minskningen mellan 2 och 12 veckor har en stor spridning från 7 cm reduktion till 5 cm omfångsökning (Fig III:3).



Figur III:3. Distala omfångets förändring mellan 2 och 12 veckor efter amputation. Korset anger medelvärde och standardavvikelse.

Genom att använda det proximala respektive det distala omfånget och längden kunde en volym beräknas som vid en stympad kon. Denna beräkning vid 2, 4, 6 och 12 veckor efter amputation visade en kontinuerlig minskning med den största minskningen från 2 till 4 veckor och med en total volymminskning under andra till tolfte veckan på omkring 7 %.

Klassifikationsformuläret användes på olika amputationsnivåer, 116 av de 135 mätningarna gällde underbensstumpar,

I gruppen underbensstumpar användes en proportionell indelning i korta, ordinära och långa. Kvoten längd/bredd var mindre än 1 i 15/116 (13 %), mellan 1 och 2 i 94/116 (81 %) och större än 2 i 7/116 (6 %). Stumpen var cylindrisk i 80 %, konisk i 19 % och klubbformad i 1 %. Ärret var välläkt i 77 % och adherent i 9 % (Figur III:1).

Huden var oskadad i 70 % av alla stumpar utan skillnad mellan lårben och underbensnivåer (Tabell III:1) och stumpar äldre än 1 år hade en signifikant högre proportion hudskador ($p < 0.005$).

Tabell III:1 Hudens kondition bland lårbensamputerade (AK) och underbensamputerade (BK).

Kondition	AK	BK
Oskadad	9	81
Skav	1	8
Sår	-	5
Infekterat sår	-	5
Epidermoidcysta	1	2
Sugmissfärgning	-	4
Blåsa	-	1
Vårtig förtjockning	-	1
Hudkörtelinflammation	1	1
Eksem	-	1
Totalt	12	109

Underbensstumpen tenderade att bli mera spetsig med tiden. Vid mätning under första året var 10/59 spetsiga jämfört med 12/42 mätt mer än ett år efter amputationen.

Protesteknisk korrektion behövdes hos en av 12 lårbensamputerade och hos åtta av 116 underbensamputerade. Kirurgisk korrektion behövdes hos en i vardera gruppen.

MÄTNING AV MAXIMAL ÄNDBELASTNINGSFÖRMÅGA HOS BENAMPUTERADE (ARTIKEL IV)

INTRODUKTION

Amputationer genom knäleder eller fotleder ger funktionellt mycket goda stumpar. Detta beror på den långa hävarmen, den pålitliga upphängningen genom den vidgade stumpändan samt den höga ändbelastningsförmågan genom den rundade benändan och den stora ytan (Hornby och Harris 1975). För att öka den distala ytan vid vanliga transmedullära amputationer har Swanson (1972) använt en silastikplugg som inplanterats i mörghålan. Dederich (1963) och andra har utfört en osteoplastik för att överbrygga ben mellan fibula och tibia. Foort (1981) föreslår att t ex femurkondylerna används som autotransplanterat för att öka amputationsstumpens ändbelastningsförmåga.

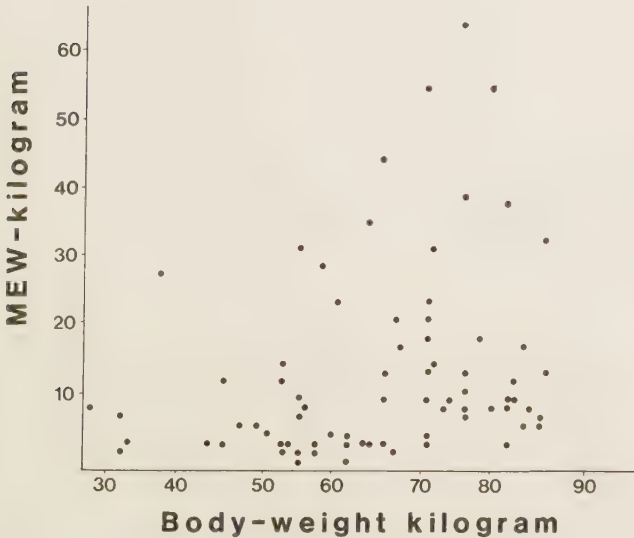
Äldre typer av proteser tillverkades antingen för stumpändebelastning eller för proximal upphängning. Moderna proteser använder huvudsakligen totalkontakt men vissa delar av stumpen utsätts för högre belastning. Renström (1981) har i en serie av underbensstumpar följt den maximala ändbelastningsförmågan under ett rehabiliteringsförlopp med hjälp av en personvåg och visat att denna ökar vid träning men ej systematiskt studerat hur den varierar vid olika förhållanden i övrigt. Vår studie är gjord för att systematiskt undersöka hur den maximala ändbelastningsförmågan varierar vid olika amputationsnivåer, diagnoser, stumpformer och typer av smärta, med tanke på att sådan kunskap skulle kunna möjliggöra en mera individuell fördelning av trycket i en totalkontaktthylsa.

MATERIAL OCH METOD

I en serie av 69 patienter med läkta stumpar utfördes 102 mätningar; 9 var bilateralt amputerade. Upprepade mätningar gjordes således i 24 fall och med ett intervall på 1-9 månader. För mätningarna användes en personvåg av fjädertyp (EKS- 0-120 kg, Holland) monterad på en ställning, som var justerbar i höjd. Mätningen gjordes stående 2 eller 3 gånger och högsta värdet noterades.

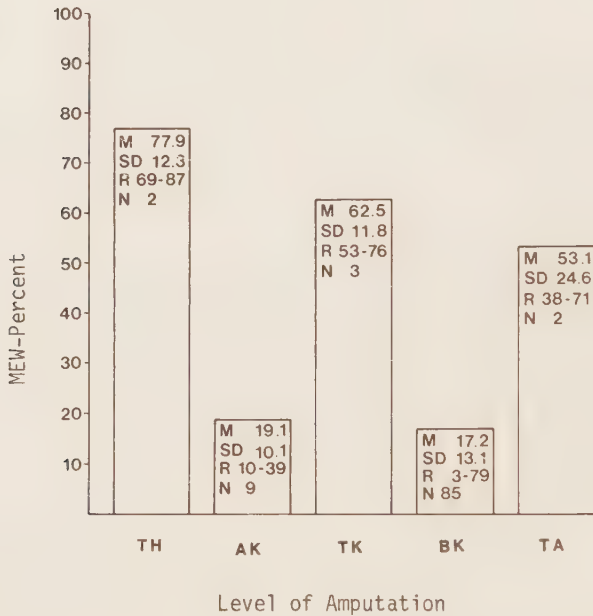
RESULTAT

Den maximala ändbelastningsförmågan (MEW=Maximal End Weight-bearing) var 13.3 (SD 10.7) för män och 7.9 (SD 5.3) kg hos kvinnor med underbensamputation. Maximala ändbelastningsförmågan varierade med kroppsvikten och MEW anges därför i % av kroppsvikten (MEW-procent frånsett i Figur IV:1).



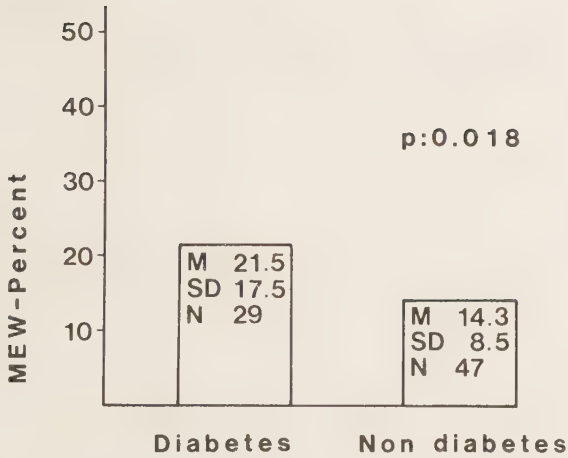
Figur IV:1 Samvariationen mellan kroppsvikt och ändbelastningsförmåga hos underbensstumpar. ($Y=0.3+0.2X$) ($N=101$. $P=0.001$).

Uppdelning på amputationsnivå av ändbelastningen visade att denna varierade kraftigt mellan exartikulationer och transmedullär amputationer. (Figur IV:2).



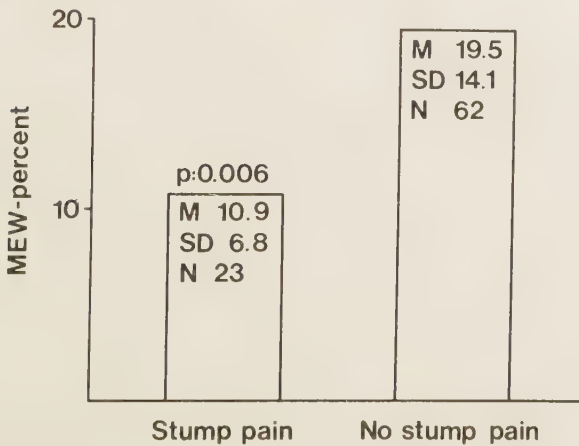
Figur IV:2 Maximal ändbelastning, MEW-procent, varierar med amputationsnivå. TH= genom höft, AK= ovan knä, TK= genom knä, BK= nedan knä, TA= genom ankelled. M= medelvärde, SD= standarddeviation, R= spridning, N= antal.

Många patienter med hög ändbelastningsförmåga efter underbensamputation var diabetiker och det förelåg en högre ändbelastningsförmåga hos diabetiker med i genomsnitt 22 % av kroppsvikten jämfört med 14 % av kroppsvikten hos icke diabetiker $p=0.018$ (Figur IV:3). Neuropatin hos diabetiker skulle kunna orsaka ett ökat antal stumpar med hudskada vilket dock ej kunde verifieras.



Figur IV:3 Maximal ändbelastning, MEW-procent, hos underbensamputerade med och utan diabetes.

Den maximala ändbelastningsförmågan begränsas av smärttoleransen. Patienter med stumpsmärta och fantomsmärta analyserades separat. Belastningsförmågan föll från 19.5 utan till 10.9 MEW-procent med stumpsmärta ($P=0.006$) (Figur IV:4), medan fantomsmärta ej orsakade signifikant sänkning.



Figur IV:4 Maximal ändbelastning, MEW-procent, hos underbensamputerade med och utan stumpsmärta.

Ändbelastningsförmågan vid spetsig respektive rundad stump-
ände var relativt oförändrad även efter korrektion för
stumpålder.

TOLERANSEN FÖR TIDIG GÅNGTRÄNING MED TOTALKONTAKT EFTER UNDERBENSAMPUTATION - EN RANDOMISERAD UNDERSÖKNING (ARTIKEL V)

INTRODUKTION

Omedelbar protesförsörjning infördes av Berlemont (1961) och Weiss (1969) men de som amputerats pga kärlsjukdom tolererade detta sämre än traumafall (Cohen et al. 1974). Tidig protesförsörjning i stället för omedelbar blev istället vanlig. Bland dessa huvudsakligen äldre patienter finns en tendens att vänta med protesförsörjningen för att försäkra sig om säker läkning och för att förhindra upprepade protesbyten pga postoperativ volymförändring. Det behövs därför enkla temporära proteser för den första gångträningen. Olika typer har konstruerats, somliga med tuberbärning (Devas 1977; Hierton 1980). Andra har använt uppblåsbara proteser (Little 1971; Kerstein 1974; Redhead et al. 1978). Andra temporära proteser av olika material har också använts (Ruder et al. 1977; Winkler och Fitzlaff 1980).

Den prefabricerade temporära protes som testats i denna undersökning är en totalkontaktprotes som formas på stumpen när den sätts på (Henriksen et al. 1977), och tillverkas i en storlek. Protesträningen kräver därför ej något deltagande från ortopedteknisk verkstad. Syftet var att undersöka om nyamputerade kunde tåla totalkontakthylsa och belastning med protes efter gipsperioden på 2 veckor.

MATERIAL OCH METOD

Av 169 patienter hade 79 jämnt födelsedatum och randomiserades till träningsprotesgruppen. Alla underbensamputationerna var gjorda på grund av kärlsjukdom och alla utom en med sagital teknik. Patienter som avled inom 3 månader efter amputationen eller reamputerades exkluderades från studien. Uppföljning var omöjlig hos några patienter som bodde långt från sjukhuset. Sju patienter följde ej genomförd randomisering (Tabell V:1).

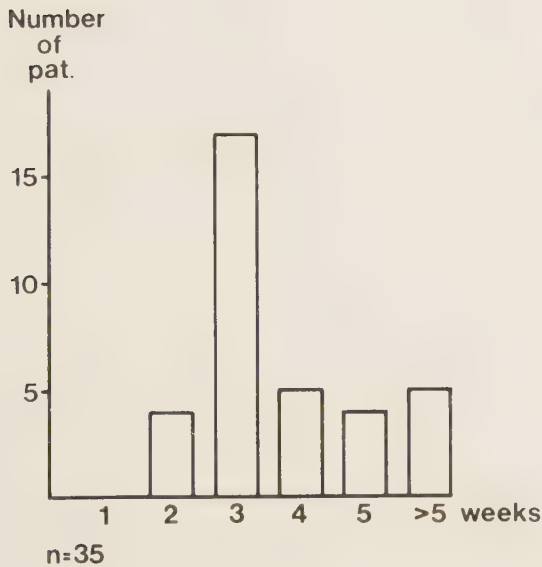
Tabell V:1 Materialbeskrivning och läkningsresultat.

Resultat	Tränings- protesgrupp	Kontroll- grupp
Döda	16	17
Reamputerade	8	9
Ej följda kliniskt	8	9
Följde ej randomisering	0	7
Primärläkta (6 v)	25	21
Sekundärläkta	10	12
Läkta med sekundära sårnader	12	15
Totalt	79	90

Stumpens läkning och patientens allmäntillstånd avgjorde om protesträning var möjlig. I träningsprotesgruppen kunde 35 av 47 använda protesen, i kontrollgruppen fick 9 av 48 använda annan protes utan totalkontakt (tuberbärande) medan 39 av 48 var utan protes.

Träningsprotesen med totalkontakt hade en hylsa i form av en plastkudde med små plastkulor som blev semirigid när luften evakuerades. Hylsan fästes sedan i en 4-bladig öppen hylsa på ett rörskelett med en fot applicerad. Längd- och rotationsjustering var möjlig (Tulpanprotes, LIC, Solna).

RESULTAT



Figur V:1 Tid från amputation till första träningen med träningsprotesen.

Träningsprotesen började användas 2-3 veckor efter amputationen (Figur V:1) och träningen varade som regel 2-3 veckor. Sekundära sårnader på den läkta stumpen förekom i båda grupperna (Tabell V:1). Endast i ett fall hade dock träningspro-

tesen använts före det den sekundära sårnaden uppstod, och patienten började i detta fall endast 15 dagar efter amputationen att träna med totalkontaktträningsprotesen.

Sju patienter började totalkontaktprotestrainingen innan amputationsstumpen var läkt. I två fall utfördes reamputation (träningen började 19 respektive 20 dagar efter amputationen), i ett fall ökade sårdiastasen innan såret sedan läkte och i fyra fall läkte såren under fortsatt försiktig träning.

Någon skillnad i tiden från amputation till definitiv protes förelåg ej i de två grupperna. Gångförmågan mätt som antal gångstöd tre månader efter amputationen visade inte heller någon skillnad mellan grupperna. Endast 10 patienter gick med mindre än två gångstöd vid tre månaderskontrollen. Vårdtiden påverkades ej av träningsprotesen.

DISKUSSION OM EGENSKAPER HOS AMPUTATIONSSTUMPAR OCH TOLERANSEN FÖR TIDIG TRÄNING MED TOTALKONTAKTPROTES

Den stora andelen mycket gamla ökar behovet av objektiv stumpvärdering under olika stadier av rehabiliteringsförloppet. Att registrera alla aspekter på en amputationsstump skulle föra till ett ohanterligt protokoll, medan å andra sidan osystematisk bedömning lätt kan göra att väsentliga observationer försummas. Levy (1980) har gjort en utförlig beskrivning av hudens problem men övriga stumpkarakteristika har ägnats litet intresse i litteraturen. Isherwood et al (1973) och Weiss et al (1971) har publicerat mätningar av tryckförhållande och smärtfaktorer. Föreliggande arbete har försökt sammanföra de viktigaste faktorerna till ett kort men relevant formulär vilket testats. När det gäller en så fundamental sak som längden på en amputationsstump har den proportionella längden använts i stället för tidigare absoluta eller relativa längder i förhållande till andra sidan. Grovleken kommer härigenom fram på ett mer realistiskt sätt eftersom hylsans möjlighet att sitta stadigt så mycket beror härpå liksom på stumpens fasthet. Stumpändens mjukdelsteckning och smärttålighet spelar vidare stor roll vid belastning i moderna proteser som utnyttjar totalkontakt.

I denna studie har Renströms (1981) teknik att bedöma ändbelastningskapaciteten prövats systematiskt och relaterats till olika nivåer, indikationer och smärtförhållanden. Renström (1981) fann att träning ökade ändbelastningsförmågan hos underbensamputerade. En liknande teknik att pröva ändbelastning med en våg har använts av Hornby och Harris (1975) men enbart på Syme-amputerade patienter. Fyndet att diabetiker tålde en högre belastning var en överraskning men kan förklaras av förekomsten av polyneuropati. Att fantomsmärtefallen tålde mer än stumpsmärtefallen är också värt att observera och kan kanske vara till hjälp

vid analys av problem. Tekniken att pröva ändbelastningstoleransen med en personvåg är en grov förenkling som bortser från ytornas storlek, belastningens tid och upprepning samt sidokrafter etc men tycks ändå vara ett värdefullt tillskott till stumpundersökningen. Denna skall leda fram till ett beslut om huruvida kirurgiska eller protestekniska åtgärder kan vidtagas för att förbättra patientens situation.

Rehabiliteringen av protesgångare bör ske i samråd mellan ortoped, ortopedingenjör och sjukgymnast så att de olika aspekterna på problemen iakttages. I denna studie har emellertid ingen detaljerad diskussion förts om protestekniska problem och på samma sätt har sjukgymnastiska metoder inte ägnats någon analys. Båda dessa aspekter är emellertid viktiga för ett utvecklat rehabiliteringsprogram. Nya aspekter för protesträning har t ex nyligen publicerats av Renström (1981), utvisande att en stumpträning koncentrerad på muskulaturen med instruktionen att röra i den bortamputerade delen kan leda till förbättrad funktion.

Stumpproblemen under de första månaderna gäller smärta, sårsläkning, avsvullnad och belastningstolerans. Den stora förekomsten av sårproblem under det tidiga förloppet gör tveksamhet naturlig till tidig protesanvändning och motiverade den randomiserade studien vilken tidigare ej gjorts för att belysa dessa problem. Det har sagts att man vid kärlsjukdom ej bör använda tidig protesträning och inte totalkontaktthylsa (Mooney 1971 och Cohen et al 1974). Den enkla träningsprotes i standardstorlek, som prövats ger totalkontakt och tålde väl vid användning på välläkta stumpar minst tre veckor efter amputationen. Det skall dock framhållas att det är fråga om ett träningshjälpmedel i två pass om högst en timme dagligen. Träningen upplevdes mycket positivt men syntes ej påverka vårdtider och antalet gånghjälpmedel. Nu finns ett flertal olika

träningsproteser att tillgå. Några är tuberbärande och avlastar stumpen men med risk att skapa ödem (Devas 1977, Hierton 1980). Luftkuddeprincipen (Little 1971, Kerstein 1974, Redhead et al 1978) ger god stumpavlastning men är skrymmande att gå med, låser knäet i sträckställning och genom att amputationsstumpen är instängd i plast ger den problem med transpirationen (Leibacher et al 1978). Den i studien prövade träningsprotesen är mindre skrymmande, medger en liten rörelse i knäleden och låter transpirationen absorberas av binda och tyg. Träningsprotesen kan med fördel användas till aktivering och tidig gångträning och bör ingå som ett naturligt led i den fysikaliska terapin utan att man behöver befara skada på stumpläkningen eller fördröjning av den definitiva protesens.

SOCIAL OCH MEDICINSK BAKGRUND SAMT FÖRUTSÄGELSE OM REHABILITERINGEN EFTER AMPUTATION FÖR KÄRLSJKDOM (ARTIKEL VI).

Antalet amputationer för kärlsjukdom ökar hos äldre och det kan ibland synas vara slöseri av resurser att genomföra gångrehabiliteringsförsök (Davis et al 1967). Trots att dödligheten är hög och långvård ofta blir nödvändig bör dock inriktningen vara att rehabilitera de amputerade att kunna gå och om möjligt återvända hem. Denna studie gjordes för att värdera hur rehabiliteringen lyckades. Patienterna studerades ur social och medicinsk synpunkt med syftet att bedöma viktigare prognostiska faktorer.

MATERIAL OCH METOD

I en arbetsgrupp med arbetsterapeut, kurator, ortopedkirurg, sjukgymnast samt sekreterarhjälp insamlades uppgifter om patienternas medicinska och sociala förhållanden. Tvåhundra- elva amputationer på nedre extremiteten hos 182 patienter studerades. Medelåldern var 77 år, hos män 75 och hos kvinnor 79. 84 % av amputationerna gjordes primärt på underbenet (Tabell VI:1). Alla underbensamputationer utom en var utförd med sagittal teknik (Persson 1974). Etthundatrettio- tre patienter var ensidigt benamputerade.

Tabell VI:1 Primär och slutlig amputationsnivå.

Nivå	Totalt	Under knä	Genom knä	Över knä	Andel under knä
Primär	211	178	4	29	.84
Slutlig	211	157	4	50	.74

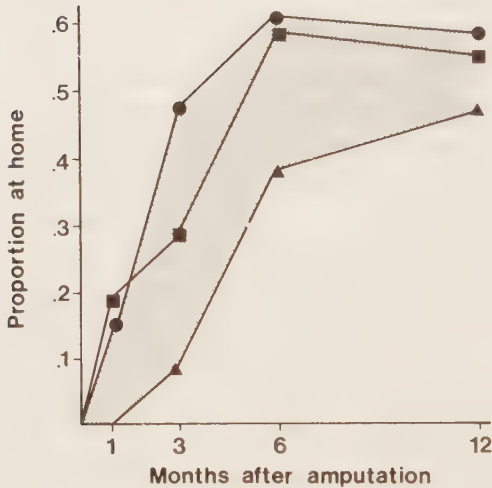
RESULTAT

Social bakgrund. Sjuttiotvå av de 182 patienterna bodde tillsammans med någon, 143 var pensionerade, 22 förtids-pensionerade och endast fem arbetade heltid under de sista fem åren. Under året före amputationen hade 39 hjälp i hemmet. Ett år efter amputationen hade 25 av de 57 som bodde i eget hem hjälp.

Medicinsk bakgrund. Av de 182 patienterna var 45 behandlade för högt blodtryck, 35 hade haft hjärtinfarkt och 39 hade haft hjärnblödning; 62 patienter hade en av ovanstående medan 26 hade kombinationer. Etthundrafemtiofem hade vårdats för kärlsjukdom på sjukhus någon gång under de sista fem åren. Kärlkirurgisk bedömning var gjord i 140 av 211 amputationer. Den direkta orsaken till amputation visade att septisk eller toxisk påverkan var vanligare hos lårbensamputerade än underbensamputerade ($p < 0.001$). Bland de 182 patienterna hade 59 diabetes. Medelintervallet från diagnos till amputation var 13 år. Av 123 utan diabetes hade 37 ett plötsligt insjuknande som vid trombos eller embolism. Amputationsnivån fastställdes genom klinisk undersökning; den peroperativa bedömningen av läkningsutsikterna överensstämde med läkningsresultatet ($p < 0.001$). Reamputation utfördes på 16/59 efter kärlkirurgi jämfört med 5/119 utan ($p < 0.001$). I kärlkirurgigruppen utfördes 15 reamputationer efter embolektomi eller mer än en kärlkirurgisk operation. Någon skillnad i reamputationsfrekvens mellan diabetiker och icke-diabetiker fanns ej.

Rehabilitering. Medelvårdtiden på kliniken var 47 dagar. Pro-
testträning skedde vid ytterligare vårdtillfällen i 39 fall med en medelvårdtid på 20 dagar. Mortaliteten var hög med 68/182 döda inom ett år. Fördrojd sårläggning och reamputation påverkade vårdtidens längd men rehabiliteringen till eget hem var ej signifikant påverkad (Fig VI:1). Definitiv protes levererades till 100 av de 157 läkta underbensampu-

tationerna, inte efter någon av fyra knäledsexartikulationer och bara till fyra av de 29 primärt lårbensamputerade samt till åtta av de 21 reamputerade.



Figur VI:1 Andel patienter som återvände till eget hem efter underbensamputation och sårläkning. Den skuggade ytan utgöres av förlängd vårdtid beroende på sårläkningen.

● Primärläkt = läkt inom 6 veckor.

■ Sekundärläkt = läkt på samma nivå.

▲ Reamputerad till högre nivå.

Av 76 patienter där hembesök gjorts efter ett år i eget eller hemliknande miljö med service (ålderdomshem, pensionärshem och dylikt) använde 62 proteserna dagligen och för gång. Hälften av proteserna passade bra och hälften behövde justeras. Undersökningen av hur patienterna klarade

sin dagliga livsföring (ADL-status) jämfördes tre månader före och sex månader efter amputation hos 68 i hem eller hemliknande miljö. Förändring av förmågan att själv kunna bada eller duscha och resa sig själv efter fall påverkades mest (Tabell VI:2).

TABELL VI:2 Andel som klarar funktionen utan hjälp efter underbensamputation. Alla patienterna bodde i eget hem eller hemliknande miljö ett år före amputationen. N=68.

Funktion	3 månader före	6 månader efter
Plocka från golvet	.66	.64 (NS)
Gå inomhus	.87	.81 (NS)
Använda taxi eller tåg	.53	.41 (NS)
Resa sig från stol	.94	.85 (NS)
Gå till närservice	.58	.36 (NS)
Gå i trappor	.69	.47 (NS)
Bada eller duscha	.81	.46 ($p<0.001$)
Resa sig efter fall	.73	.31 ($p<0.001$)

Förmågan att återvända till eget hem efter underbensamputation jämfördes med ålder, hälsa, samboende och bilateral amputation. Åldern vid amputation påverkade möjligheten att återvända hem. Patienter under 80 år återvände oftare hem (51/84) jämfört med dem som var 80 år eller mera (8/24) ($p < 0,05$). Om patienten hade gott hälsotillstånd påverkade detta starkt möjligheten att komma hem ($p = 0,001$). Amputerade som bodde tillsammans med någon återvände hem i mycket större utsträckning än de som bodde ensamma ($p < 0,001$) (Tabell VI:3). Däremot återvände lika många hem efter ensidig underbensamputation som efter dubbelsidig. Möjligheten att komma hem efter en reamputation från underbensamputation till lårbensamputation påverkades ej heller signifikant när det gäller resultatet efter ett år men rehabiliteringen fördröjdes (Figur VI:3).

Tabell VI:3 Andel patienter som återvände hem inom ett år jämfört med hälsotillstånd och samboende. N=108.

Hälsotillstånd och samboende	Andel hemma
Frisk, samboende	.88
Frisk, ensamboende	.63
Ej frisk, samboende	.48
Ej frisk, ensamboende	.08
Totalt	.55

DISKUSSION OM SOCIAL OCH MEDICINSK BAKGRUND SAMT REHABILITERINGEN

Grundprincipen är att en patient ej kan rehabiliteras till en vårdnivå som innebär mindre hjälp och tillsyn än patienten hade tidigare (Ceder 1980). Av de 104 patienter som ett år före underbensamputationen bodde i eget hem återvände 53 inom ett år medan 16 vistades i hemliknande miljö med service. Av återstoden hade 23 avlidit och resten fanns fortfarande i sjukhusvård. Två tredjedelar boende relativt självständigt skiljer sig ej säkert från Jensens (1982B) resultat med hälften boende självständigt efter amputation genom knäled. I Lundaundersökningen kunde de som reamputerats från underben till lårben återvända hem i nästan lika stor utsträckning som de primärläktade men först efter en betydligt längre sjukhusvård. Rehabiliteringen bestäms i hög grad av faktorer som ej kan påverkas, såsom ålder, hälsotillstånd och samboende.

Rehabiliteringsresultatet påverkas av amputationsnivån. Fram till slutet av 60-talet valde man lårbensamputation för att få en säker läkning och bortsåg från den stora funktionella förlusten (Pedersen 1968). Från omkring 1970 har många krafter emellertid verkat för att bevara knäleden. Metoder att förutsäga läkningsförmåga och förbättrade tekniker för amputation blev härvid av central betydelse. Med konventionell teknik redovisade Sarmiento och medarbetare (1970) omkring 2/3 underbensamputationer mot tidigare 1/3. Genom införande av en bakre lambåteknik (Bickel 1943) kunde Romano och Burgess (1971) redovisa hela 84 % bevarade knäleder primärt och efter 8 % reamputationer slutgiltigt 76 %, dvs samma resultat som här. Med användning av en sådan bakre lambå skulle man utnyttja hud och muskulatur med bättre cirkulation och avlägsna den känsliga huden framför skenbenet så mycket som möjligt. Liknande tankegångar ligger bakom den sagittala tekniken (Robb et al 1965, Tracy 1966 och Persson 1971, 1974). Termansen

(1977) har med randomiserad teknik visat att läkningsresultaten är desamma vid bakre lambå som vid sagittal teknik och jämförelser med andra serier visar att dessa två tekniker är bättre än den konventionella lambåplaceringen (Netz et al 1982). Allmän atraumatisk teknik utan fridissektion av olika lager, myoplastik med lagom spänning i den återsydda muskulaturen (Weiss 1969, Hansen-Leth 1982), peroperativ antibiotikatillförsel samt postoperativ bandagering spelar sannolikt stor roll. Grundläggande är emellertid ambitionen att genomföra amputationen distalt och för att få stöd för ett sådant beslut kan olika fysiologiska mätmetoder tillgripas (Holstein et al 1979). Det är redan sedan länge känt att läkning kan erhållas utan palpabla pulsar liksom att en angiografi som visar dålig fyllnad av stora kärl ej utesluter stumpläkning nedom knäleden.

Speciella mätmetoder av olika slag har prövats sedan länge som till exempel hudtemperaturmätningar och intrakutan morfininjektion enligt Haxthausen (Walheim 1945). Härvid kommer emellertid inflammationstecken och hudens reaktivitet att spela större roll än det egentliga flödet. Fysiologiska mätmetoder som pulspletysmografi och pulsmätning med Doppler-teknik (Barnes et al 1976) har prövats med viss framgång. På senare år har laser-Doppler introducerats (Jernberger et al 1982). Den har fördelen av att mäta den ytliga kutana cirkulationen men mäter ej det djupare pulsatila flödet. Nyligen har också så kallad flourescein-angiografi visats underlätta nivåvalet i någon mån (Tanzer et al 1982). Tillförsel av radioaktiva isotoper och successiv främsläppning av blod genom sänkning av trycket i en manschett ger en så kallad utsköljningshastighet och mäter det kapillära blodtrycket (Holstein et al 1979). Denna metod är besvärlig för patienten i motsats till Doppler och laser-Doppler samt den nyligen introducerade fotoelektriska tekniken (Stöckel och Bröchner-Mortensen 1982).

De material som publicerats om mätning av cirkulationen har inte visat högre proportion bevarad knäled eller lägre proportion reamputationer än Lundamaterialets 84 % primärt bevarad knäled och 10 % reamputation. Med användning av Holsteins isotoputsköljningsteknik hade Jensen et al (1982) exempelvis 20 % reamputationer och slutgiltigt 36 % bevarad knäled samt 18 % amputationer genom knäleden i en serie av 320 patienter. Man kan förmoda att mätteknikerna kan utvecklas så att läkningen kan förutses (Symes et al 1982) vilket innebär att man nu bör kombinera klinisk bedömning med mätteknik och ställa dessa fynd i förhållande till vilka patienter som är särskilt svårbedömda. Lundamaterialet visade att 16 av 59 kärlopererade patienter hade reamputerats mot fem av 119 patienter som ej genomgått någon kärloperation före amputationen ($p < 0.001$). En mätning av cirkulationsförhållandena i denna kärlopererade grupp hade kanske minskat antalet reamputationer. Problemet med alla mätmetoder är att gränsen för acceptabel cirkulation är svår att bestämma. Sätter man gränsen vid en viss nivå, t ex 30 % av armbloodtrycket så innebär det en risk att vissa patienter hade kunnat läka fastän de hade dåligt preoperativt mätvärde. En av orsakerna härtill är att cirkulationen förbättras till följd av amputationen vilket visats av flera författare (Holstein et al 1979, Hansen-Leth 1982).

Kärlkirurgiskt opererade patienter är således svårbedömda och det har tidigare ifrågasatts om inte kärlkirurgin när den misslyckats i att rekonstruera flödet i stället skapar en sämre amputationsnivå. Burgess (1974) fann emellertid ingen skillnad i läkning bland amputerade med eller utan föregående rekonstruktiv kärlkirurgi. Siffrorna i Lundamaterialet visar att patienter efter embolektomi eller upprepa-de kärlingrepp vid underbensamputation hade signifikant sämre läkning medan endast en av dem som elektivt engångsopererats reamputerades.

En fråga i samband med kärllirurgiska aspekter är om dessa amputationer bäst sköts av ortopeder eller allmänkirurger. I Stockholmsområdet var verksamheten lika fördelad. Det är viktigt att analysera nivåval och läkning. Utvecklingen inom amputationskirurgi, rehabilitering och protesteknik bör behärskas av operatören och resurser bör därför skapas för att de ortopediska klinikerne kan överta all amputationskirurgi (Netz et al 1982). Vid Lunds lasarett har ortoped-kirurg utfört alla amputationer och sedan 1971 har t ex den primära amputationsnivån för varje år varit mellan 70 och 90 procent (Persson et al 1981).

Diabetesförekomstens betydelse för läkningen och nivån har analyserats tidigare. Renström (1981) redovisade bättre läkning hos diabetiker efter underbensamputation. I Lunda-serien fanns ingen skillnad i reamputationsfrekvens mellan diabetiker och icke-diabetiker medan man däremot tidigare funnit att proportionen bevarade knäleder blir högre hos diabetiker än hos icke-diabetiker (Warren och Kihn 1968, Persson 1974). Förekomst av goda stora kärl hos diabetiker kan förklara detta. Den intensifierade satsningen på vården av diabetesfötter och undvikande av amputation kan i kombination med förbättrade mätmetoder göra att denna skillnad efter hand försvinner (Wagner 1981).

Vid tveksamhet i valet av amputationsnivå kan knäledsamputation vara ett alternativ (Jensen et al 1982B) med god protesfunktion. Även Jernberger och Tryggö (1982) har betonat värdet av knäamputation men också deras siffror visar att ett utnyttjande härav i viss grad sker på bekostnad av andelen underbensamputerade.

Protesrehabilitering ställer krav både på amputationsstumpen och på patientens allmäntillstånd. Det är välkänt att lårbensamputerade har svårare med av- och påtagning än underbensamputerade (Brunk et al 1974) och att gången med lårbensprotes är mycket energikrävande (James och

Nordgren 1973). Det anges vanligen att $2/3$ av underbensamputerade efter kärlsjukdom kan protesrehabiliteras mot endast $1/3$ av lårbensamputerade (Warren och Kihn 1969, Coach et al 1977, Renström 1981). Samma andel protesrehabilitering för underbensamputerade förelåg i denna undersökning men en ännu lägre andel för lårbensamputerade. Detta beror sannolikt på att lårbensamputation endast har använts i ett ringa antal fall, ofta med dåligt allmäntillstånd. Davis et al (1967) anger att hälften ej använde proteserna efter två år. Av de som bodde i eget hem eller hemliknande miljö med service använde 62 av 76 underbensamputerade sin utskrivna protes efter ett år.

Förutsägelse av rehabiliteringsresultatet på basen av kända kriterier vid amputationstillfället är till hjälp för planering av rehabiliteringen och för planering av vårdbehovet (Jansen et al 1980). Ceder och medarbetare (1981) har visat hur en sådan metod kan användas för höftfrakturpatienter. För patienter som amputerats för kärlsjukdom har det således visats hur ålder, samboende, medicinskt allmäntillstånd och amputationsnivå är avgörande. Prediktionstalet för att återvända till eget hem inom ett år efter underbensamputation var för ensamstående, ej friska 0,1 men hos den gynnsammaste gruppen 0,9.

SAMMANFATTNING

Amputationer för kärlsjukdom har ökat mer än 10 gånger sedan 1910 och 5 gånger sedan 1950. Incidensen var 1979 i Malmöhus län 0.1 per 1000 i åldersgruppen 40-59 år och successivt stigande till 3.8 för åldersgruppen 80 år och däröver. Andelen minst 80 år gamla hade även ökat fyra gånger bland amputerade under de sista 30 åren till nu 38 %. Den totala incidensen var 0.3 per 1000 invånare. Med korrektion för det ökade antalet åldringar i befolkningen var ökningen fyra gånger från 1910 till 1979.

Förutom förändringar i befolkningsprofilen är förekomsten av diabetiker och rökare i befolkningen möjliga orsaker till ökningen. Andelen diabetiker i skandinaviska amputationsmaterial synes i stort sett oförändrad under de senaste decennierna med 37 % i incidensundersökningen för Malmöhus län 1979. Att också rökning påverkar kärlsjukdom har påvisats men det synes ej finnas någon undersökning där detta korrelerats till amputation och till ålders- och könsmatchat kontrollmaterial ur befolkningen. Denna undersökning avseende ålder, diabetes och rökning med 188 patienter visade att det endast fanns 23 som varken var minst 80 år, rökare eller diabetiker och av dessa 23 var amputationsorsaken tromboembolisjukdom i 12 av fallen. Av 100 män hade 75 varit dagligrökare, vilket i det närmaste motsvarades av förekomsten i kontrollmaterialet medan de som fortsatt att röka var överrepresenterade ($p < 0.002$) i amputationsgruppen. Män som aldrig rökt var i genomsnitt 81 år medan de som rökte minst 10 cigaretter om dagen fram till sista året för amputationen endast var 68 år. För kvinnor fanns motsvarande åldersskillnad, beroende på graden av rökning. Hos diabetiker som aldrig rökt

var åldersskillnaden hos män nio år och hos kvinnor fem år. Risken för amputation före 80 års ålder hos individer utan diabetes som aldrig rökt är obetydlig. Förekomsten av rökning bör noteras lika rutinmässigt som diabetes hos amputationspatienter.

Amputationsstumparnas egenskaper påverkar protesrehabiliteringen varför en systematisk, klinisk undersökning är viktig, särskilt hos gamla, för att upptäcka och kompensera fel. Proximalt och distalt omfång, stumplängd och förändring till 12 veckor efter amputationen studerades hos 93 underbensamputerade. Stumplängden beskrevs med ett proportionellt längdmått utvisande en medelkvot läng/bredd av 1,7. Volymminskningen uppmättes från andra till tolfte veckan till i medeltal 7 %. Ett formulär för bedömning utarbetades efter samråd med International Society for Prosthetics and Orthotics. Det användes vid 135 mätningar på 96 amputationsstumpar. Av dessa var 12 lårbensamputerade och 116 underbensamputerade. Ärret var välläkt i 80 % och adherent i 10 % bland underbensamputerade. Hudskador uppdelades i sådana som orsakats av tryck, sug, infektion och allergi.

Mätning av den maximala ändbelastningsförmågan genomfördes systematiskt. Medelvärdet hos underbensamputerade män var 13 kg och hos kvinnor 8 kg. Korrelation påvisades till kroppsvikten, amputationsnivån, förekomsten av diabetes samt typen av smärta. Diabetiker hade högre ändbelastningstolerans och patienter med stumpsmärta hade lägre än patienter med fantomsmärta.

Amputationsstumparnas förmåga att tolerera tidig belastning med totalkontaktprotes studerades därför att dåliga resultat erhållits vid omedelbar protesförsörjning vilket har lett till att protesförsörjning senarelagts. Stumpproblemen under de första månaderna gäller smärta, sårläggning,

avsvullnad och belastningstolerans. En speciell träningsprotes i standardstorlek prövades i en randomiserad serie på 169 underbensamputerade. Träningen tåldes väl, upplevdes positivt och påverkade ej statistiskt stump-läkningen. Vårdtider och gångförmågan förändrades emellertid ej.

I en konsekutiv serie av 182 amputerade med 211 amputationer följdes rehabiliteringsförloppet av ett särskilt team. En tredjedel avled under första året. Hypertoni, hjärtinfarkt eller cerebral insult förelåg hos hälften. På grund av diabetes och kärlkomplikationer var 155 vårdade på sjukhus under sammanlagt två månader under de sista fem åren. Diabetes förekom hos 59 patienter men bara i 17 fall diagnosticerades detta mindre än fem år före amputationen. Tromboembolism förorsakade 37 av amputationerna. Underbensnivå försöktes primärt i 84 % och erhöles i 74 %. Reamputationerna inträffade huvudsakligen i gruppen där tromboemboliktomi eller flera kärlkirurgiska ingrepp föregick amputation. Underbensnivå är den naturliga primära amputationsnivån. Då operatörens bedömning av läkningsmöjligheten väl överensstämmer med uppnådd läkning ($p < 0.001$) kan man vid dåliga blödningsförhållanden direkt utföra en mera proximal amputation. I fall med preoperativt svårbedömd amputationsnivå och hos patienter som opererats kärlkirurgiskt bör särskilda mätmetoder för bedömning av cirkulation användas.

Social och medicinsk anamnes ställdes i relation till rehabiliteringsresultatet. Ett år före amputationen bodde 118 patienter i eget hem och 57 återvände hem. Av 13 patienter med primär lårbensamputation återvände endast två hem och av 104 primära underbensamputationer återvände 55 hem. Reamputation från underben till lårben påverkade endast i ringa grad möjligheten att återvända hem men fördubblade vårdtiden från 42 till 81 dagar. Medelvårdtiden för samtliga patienter var 47 dagar. Patienter med bilateral underbensamputation återvände hem i lika stor utsträckning som

unilateralt underbensamputerade. Protes gavs till 100 av de 157 underbensamputerade, till fyra av de 29 primära lårbensamputationerna och till åtta av de 21 reamputerade. Förmågan att självständigt klara aktiviteter vid daglig livsföring påverkades i viss utsträckning, mest betydelsefullt när det gällde att kunna bada eller duscha och att resa sig efter ett fall.

Hälsotillstånd och samboende är de två viktigaste prognostiska faktorerna för rehabiliteringsförloppet. En ensamboende patient med nedsatt hälsotillstånd kommer åter till eget hem i endast ett fall av tio medan en samboende med gott hälsotillstånd kommer hem i nio fall av tio.

FRAMTIDSPERSPEKTIV

Fortsatt ökning av antalet amputationer kan förväntas beroende på det kraftigt ökande antalet invånare i åldern över 80 år. Amputationer för kärlsjukdom hos patienter med diabetes bör däremot kunna minskas med förbättrad behandling av diabetesfoten. Förekomsten av rökning i befolkningen visar tendens att minska. Däremot röker nu unga kvinnor mer än unga män varför könsskillnaden bland amputerade kan upphöra.

Amputationsnivån bör kunna förskjutas ytterligare distalt när utveckling av mätmetoder för bestämning av hudcirulationen har nått längre.

Social rehabilitering bestäms av faktorer som ej kan påverkas: ålder, hälsotillstånd och samboende. Fler amputationer kommer att utföras på patienter som är mycket gamla. Ökade krav kommer härigenom att ställas på vårdplatser i såväl akutvård som långvård. Patienterna har redan under de sista fem åren före amputationen vårdats på sjukhus i nästan två månader, vid amputationen en och en halv månad och efteråt för protes träning ytterligare några dagar. En sjättedel är kvar i sjukhusvården efter ett år.

Med prediktion av rehabiliteringsmöjligheterna och med hjälp i hemmet kan vårdtiden vid amputationstillfället minskas. Ett samarbete mellan sluten och öppen vård samt hemhjälporganisationen kan minska behovet av sluten vård. Hemsjukvård är ofta lämpligt för denna typ av patienter och protesproblemen kan lösas vid regelbundna kontroller på särskild protesmottagning.

ENGLISH SUMMARY

The frequency of lower limb amputations for arterial occlusive disease in Malmöhus county had increased 10-fold from 1910 to 1979. In 1979 the incidence was 0.3 per 1.000 inhabitants and 3.8 per 1.000 inhabitants 80 or more years of age. The number of inhabitants 80 years or older had increased by a factor of four. The proportion of amputees 80 years or more increased four times from 1950 and was 38 % in 1979. Only 37 % were diabetics. The increasing number of elderly explains half of the increase in amputations. The occurrence of diabetes and smoking habits was studied in 188 consecutive amputees. The material was divided into smokers, ex-smokers and non-smokers. Smoking habits were analysed separately from diabetes and sex and were compared to an age-matched control material. Male smokers were overrepresented among amputees. Smokers and diabetics were younger when amputated. The three categories, elderly, diabetics and smokers accounted for almost all of the increase in incidence of amputation seen between 1910 and 1979.

Amputation stumps were studied in 93 below-knee amputees to design a standard clinical form for measurement and classification which could be used for determining if prosthetic or surgical correction was indicated. In 10 % such correction was necessary. Maximal end weight-bearing was analysed. Men and diabetics tolerated more and patients with phantom pain more than patients with stump pain. Amputation level and body-weight were important factors. A temporary early walking aid (Tulip limb) was tested in a randomized series of 169 below-knee amputees and found to be well tolerated three weeks after surgery. Social and medical history was analysed and correlated to the rehabilitation level among 182 amputees. One third died within one year. Below-knee amputation was attempted in 84 % and achieved in 74 %. Increased reamputation rate was found following vascular surgery. Probability of returning home after amputation ranged between 0.1 and 0.9 when calculated solely on general health and co-living.

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I

INCREASED INCIDENCE OF LOWER LIMB AMPUTATION FOR ARTERIAL OCCLUSIVE DISEASE

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ABSTRACT

The number of amputations in Malmöhus county with just over 500.000 inhabitants had increased from 14 to 161 during the years 1910 to 1979 measured each fifth year comprising totally 724 observations. The number of amputations compared to the age related incidence 1979 had increased four times. Age, diabetes mellitus and sex proportions of ischemic amputees was studied and compared to other Scandinavian reports during the last 30 years. The proportion of diabetic amputees (0.37) and the male proportion (0.54) seemed unchanged, but the proportion of amputees at least 80 years old had increased from about 0.09 to 0.38.

INTRODUCTION

In Scandinavia as in other parts of western world the number of major amputations due to ischemic vascular disease is increasing (Hansson 1964, Lindholm 1964, Hierton and James 1973). In the United States of America more than 60.000 amputations are performed annually (Berardi and Keonin 1978). The county of Aalborg, Denmark, however, had no increase from 1961 through 1971 (Christensen 1976). Besides amputations vascular surgery and other hospital admissions caused by peripheral arterial insufficiency are increasing (Tibell 1971, Eickhoff 1981). Refined methods for treatment of traumatic and tumorous conditions of the limbs have reduced the need of amputation so that vascular disease now accounts for about 90% of all lower limb amputations (Renström 1981). Although the mortality in these age groups is high it should be noted that four years after initial amputation three out of four patients are still alive (Ebskov and Josephsen 1980) and many bilaterally amputated. Most studies do not account exactly for population background when reporting on amputations numbers. In this study

therefore we have analysed the incidence of amputation during an extended time period covering both medical progress and changes in diseases and population. Simultaneously the present age, sex and occurrence of diabetes mellitus was studied.

MATERIAL AND METHOD

To study the incidence of major amputations due to ischemia excluding traumatic and tumorous conditions the county surrounding the University Hospital of Lund was chosen including five other hospitals. This region is Malmöhus county and does not include the city of Malmö. The inhabitants of this county just exceed half a million, distributed between agricultural areas and five cities. The population is shown in Table 1 during the years 1910-1979 calculated into 10-year groups.

Table 1. Population in Malmöhus county, Sweden 1910-1979

Age	Year							
	1910	1920	1930	1940	1950	1960	1970	1980
0-39	184300	250800	253700	228500	222200	211500	251300	290800
40-49	38500	41600	45800	48500	56900	54400	54600	56800
50-59	33900	33400	38600	41000	45300	54000	54400	56100
60-69	25600	27300	28400	31800	35200	40400	49700	50300
70-79	14800	15900	18000	18600	22500	26300	30800	38000
80-	4000	4900	5800	6300	7400	10100	13100	16100
Total	301100	373900	390300	374700	389500	396700	453900	508100

The information of medical data before 1970 regarding major amputation of lower extremities not caused by trauma, tumour or congenital deformities was obtained from the annual reports from all six hospitals in the county. Major amputation includes below knee amputation or more proximal levels. For 1970 and later years the information was derived from the computerized medical registration maintained by the authorities. Regarding concomitant diabetes mellitus the material was further studied in case records; those getting insulin or oral antidiabetic drugs were recorded as diabetics.

RESULTS

The number of amputations due to ischemia during the years 1910 through 1979 in Malmöhus county is shown in Fig. 1. The number of amputations had increased from 14 to 161. To evaluate how the amputation figures related to different age groups of the population the amputees from 1979 were studied; 74% of ischemic amputees were above 70 and 93% above 60 years and 54% were men. 37% of the amputees were diabetics (Table 2). The rising number of elderly citizens was not enough to explain the increasing number of ischemic amputations (Fig. 2).

From the number of amputations performed in different age groups among the 161 in 1979 it was possible to ascertain age related incidences (Table 2). The yearly incidence in population 60 years or older was 1.4 per 1000. The incidence in population was 0.3 per 1000. The yearly incidence in 1970 in the population 80 years or older was 2.7 per 1000 and in 1975 2.2.

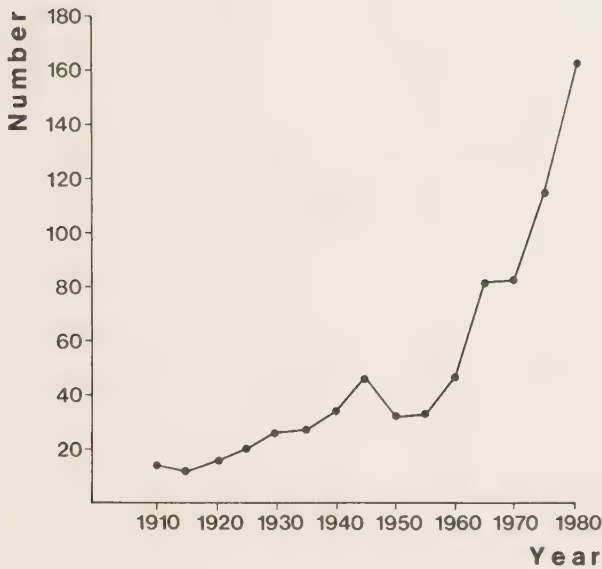


Fig. 1. Total numbers of amputations for ischemia 1910-1979 in Malmöhus county, Sweden

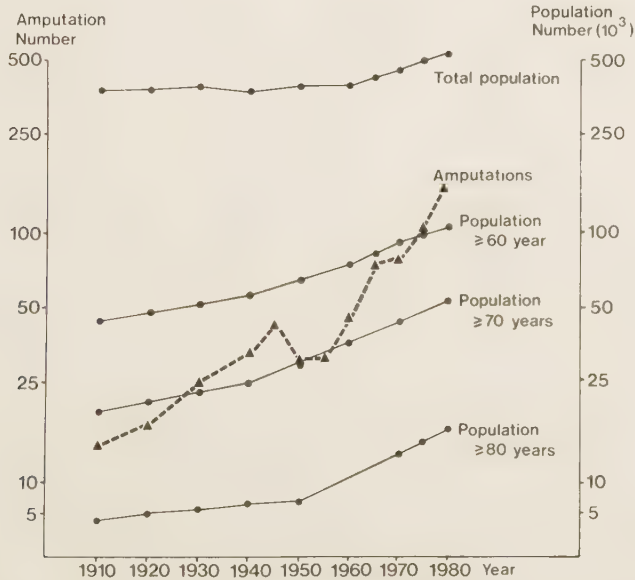


Fig. 2. Total number of amputations for ischemia in Malmöhus county 1910-1979 in relation to thousands of inhabitants in different ages and total population

From Table 2 it was possible to calculate an expected, backwards theoretically extrapolated number of amputations that should have occurred if the age related incidence had been the same during the last 70 years. The application of the age related incidences of 1979 to the population at various times gave a theoretical curve (Fig. 3). In 1910 14 amputations were performed but the extrapolated calculated number should have been 61.

This means there had been a fourfold age adjusted increase in amputations from 1910-1979. The actual number of amputations had increased more than ten times and the population at risk 60 years or more 2.4 times.

Table 2. Incidence, age, sex and diabetes of amputees in Malmöhus county, 1979.

Age group	Number of inhabitants	Number of amputations	Proportion men	Proportion diabetics	Incidence per thousand
- 40	290,800	-	-	-	-
40 - 59	112,900	11	.45	.64	.1
60 - 69	50,300	31	.65	.39	.6
70 - 79	38,000	58	.50	.34	1.5
80 -	16,100	61	.54	.34	3.8
Total	508,100	161	.54	.37	.32

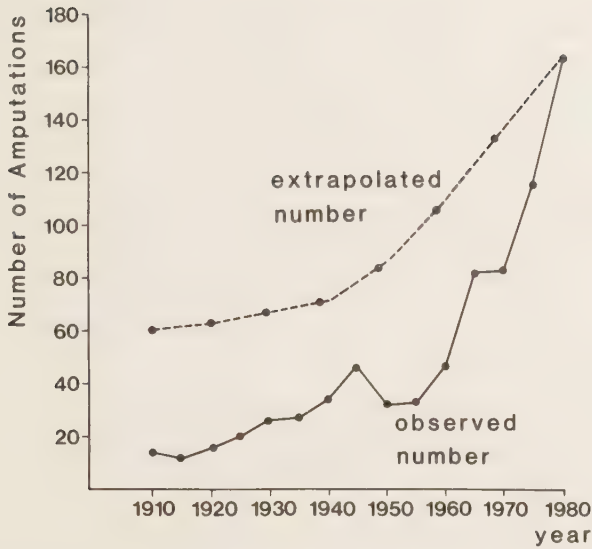


Fig. 3. Backwards extrapolated number of amputations if age related incidence had been as in 1979.

DISCUSSION

One possible reason for the increased number of major amputations for ischemic disease might be that the indications for ischemic amputations have become more liberal during the years.

The largest increase in amputation rate, however, is after 1950. It is unlikely that any significant continuous change in the indication has occurred after World War II, as different forms of anaesthesia, antibiotics, insulin and blood transfusions were available even earlier than that.

We use four possible indications for amputation (Persson 1974):

1. To save life (gangrene with septicaemia or toxemia).
2. To relieve pain (intractable despite analgesics).
3. To improve function (when a prothesis is better than the limb).
4. To solve hygienic problems (in patients severely deteriorated when life, pain and function is no longer of consideration).

It is therefore unlikely that the indication for surgery has become wider so that it can explain the increased number of amputations.

The population 80 years or older has increased from a little more than 4000 to a little more than 16000 during the studied time. The high incidence in this age group, however, does only partially explain the increase in amputations. Another possibility might be that residual life expectancy has grown so much that it would be necessary to take this into account. The residual life expectancy of 80 year old men was 5.7 years at the start of the century and 5.8 years in 1961-1965. For women the residual life expectancy has grown from 5.8 to 6.4 years (Hofsten 1975). This means that the age distribution in the population 80 or older has been similar during the studied time.

The population in the 70-79 age group had increased 2.6 times since 1910 and in this age group more than four times the total number of amputations 1910 were performed 1979. The similarity in life expectancy is important in the calculation of Fig. 3. This means that the ratio between the theoretical curve and the observed curve gives the rise in incidence with regard to the change in the age distribution of the population.

It was found that the proportion of elderly amputees had increased. From Scandinavian reports during the last 40 years a significant change towards a greater proportion of elderly amputees has occurred (Table 3).

Table 3. Proportion of patients 80 years and older at amputation for ischemia in Scandinavian studies.

Period	Authors	Number	Proportion
1949-59	Alffram & Holmquist	125	.09
1947-61	Hansson	261	.19
1950-63	Vankka	184	.12
1961-71	Christensen	326	.18
1973-77	Renström*	200	.27
1979	Present study	161	.38

* below-knee amputations only

The effect of exogenous factors like food, drugs, poisons etc could account for vascular changes at an earlier age. During this period vascular surgery has become a fairly common treatment modality with an incidence of 0.5 per thousand in the older age groups (Eickhoff 1981).

The introduction of insulin, of course, has increased the survival rate of diabetics. This could explain an increase in the number of amputees now. Even if one excludes amputations among diabetics (Fig. 3), however, the age-related incidence has grown almost three times since 1910, and the proportion of diabetics among ischemic amputees is now not more than about 37 per cent.

The number of elderly and of diabetics thus cannot alone account for the increase in amputations. It is of interest to note whether the proportion of amputations in diabetics has changed during the years, but the proportions seems unchanged ranging between .37 and .53, with the present series at the lower border. (Table 4).

Table 4. Proportion of patients with diabetes at amputation for ischemia in Scandinavian studies.

Period	Authors	Number	Proportion
1947-61	Hansson	269	.53
1949-59	Alffram & Holmquist	125	.49
1959-65	Lindahl & Bolund	183	.40
1961-71	Christensen	326	.46
1967-69	Hierton & James	94	.60
1966-71	Persson & Sundén	143	.37
1973-77	Renström*	183	.54
1979	Present study	161	.37

* below-knee amputations only

A number of Scandinavian reports concerning the sex distribution have been listed. There has been no change that indicates time related factors leading to amputation affect the sexes differently. (Table 5). The increase of ischemic amputation is unquestionable and this increase is not dependent only on age and on diabetes mellitus.

Table 5. Proportion of men at amputation for ischemia in Scandinavian studies.

Period	Authors	Number	Proportion
1930-60	Lindholm	531	.60
1947-61	Hansson	261	.54
1950-63	Vankka	184	.60
1967-69	Hierton & James	94	.44
1973-77	Renström*	200	.53
1979	Present study	161	.54

* below-knee amputations only

The increased incidence of amputation for ischemia can be explained to a limited extent by the increased number of elderly non diabetic and diabetic patients. Other contributing factors such as food, smoking habits, environmental pollution and change in physical activities require further investigation. It is possible that the notch seen in Fig. 1 during 1940-60 mirrors such environmental factors influenced by World War II.

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II

AGE, DIABETES AND SMOKING IN LOWER LIMB AMPUTATION FOR ARTERIAL OCCLUSIVE DISEASE

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ABSTRACT

The increased number of amputations for arterial occlusive disease noted in western countries is only partly explained by increasing numbers of elderly. It was therefore prospectively analysed to what extent diabetes and smoking habits influenced. 188 lower limb amputees in Lund 1978-1981 were examined and classified as non-smokers, ex-smokers, light smokers and heavy smokers. These figures were compared to corresponding figures among age-correlated controls and to a group of hip fracture patients. The material was divided into men and women and into non-diabetics and diabetics. Smokers had much lower mean age at amputation. Out of 188 amputees only 23 were not either a diabetic, a smoker or 80 years or more. The population study indicates a correlation between smoking and amputation for ischaemia. The coincident increase in cigarette consumption in Sweden is illustrated and it is suggested that smoking should be noted as regularly as diabetes at amputations.

INTRODUCTION

The growing number of elderly in the population and the prolonged survival of patients with diabetes do not explain the increase in the number of amputations (Liedberg and Persson 1983). That smoking could be a contributing factor is often mentioned, but studies dealing with the role of smoking habits among these patients seem not to be published. The old concept of Bùrgers disease among smokers (Mc Kusick et al 1962) being an inflammatory vascular process without arteriosclerosis, seems to account only for a very small proportion of amputations. This study was undertaken to analyse the smoking factor among patients amputated for ischemia of non-traumatic and nontumorous nature.

PATIENTS AND METHOD

The factors of age, diabetes and smoking habits were prospectively and consecutively studied in all 197 patients living in Malmöhus county treated for ischaemia by amputation below the knee or at more proximal in Lund from January 1978 through March 1981. Full information was not obtained in nine patients. Thus of the 188 amputees 100 were men (53 percent). Age and sex is shown in Fig 1.

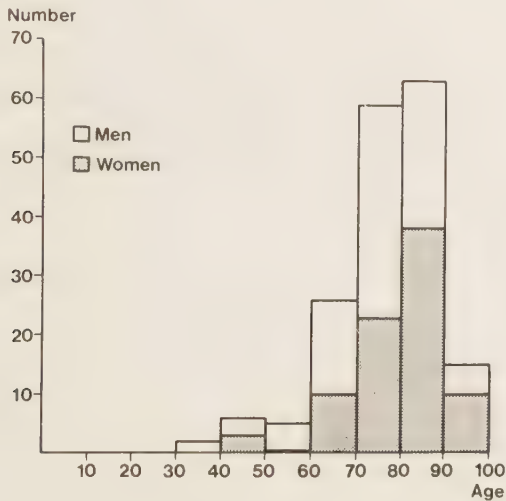


Fig. 1. Age and sex at amputation for ischemia in Lund 1978-80.

Only patients getting insulin injections or antidiabetic drugs before amputation were recorded as diabetics.

Smoking habits were classified with respect to type, amount and time for cessation. If the patients mental condition was too bad to make this information possible, the relatives were asked about it. Patients were recorded to be either non smokers, ex-smokers if they stopped more than one year before amputation, light smokers if they smoked less than 10

cigarettes a day or heavy smokers (10 cigarettes or more a day or 10 grams tobacco a day).

A control material was assembled, matched according to age and sex from the population register. Of 105 questionnaires 94 answers were obtained. An additional reference study was done concerning smoking habits among a consecutive series of patients with hip fractures.

Information about the general consumption of cigarettes, snuff and total tobacco during 1910-1980 was obtained from Swedish authorities. To illustrate some other general concomitant environmental factors information about number of cars (transportation and pollution factors) and consumption of alcohol were also added (Figs 2-5).

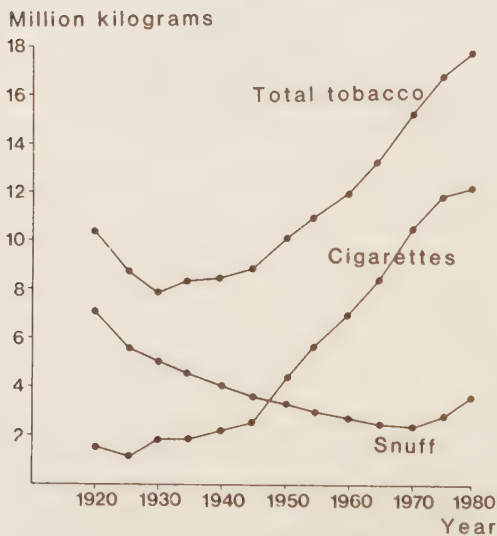


Fig. 2. Smoking and snuffing in Sweden 1920-1980.

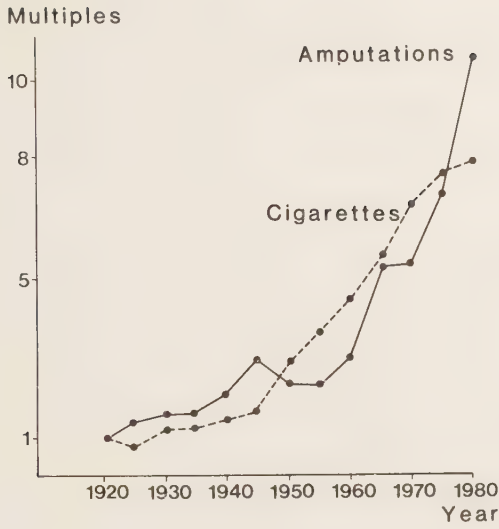


Fig. 3. Amputations and cigarettes in Sweden 1920-1980.

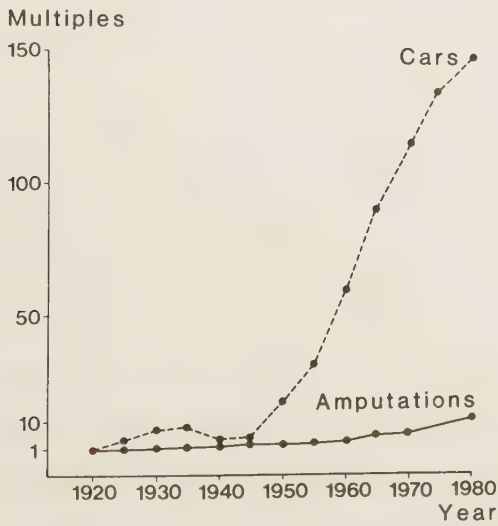


Fig. 4. Amputations and cars in Sweden 1920-1980.

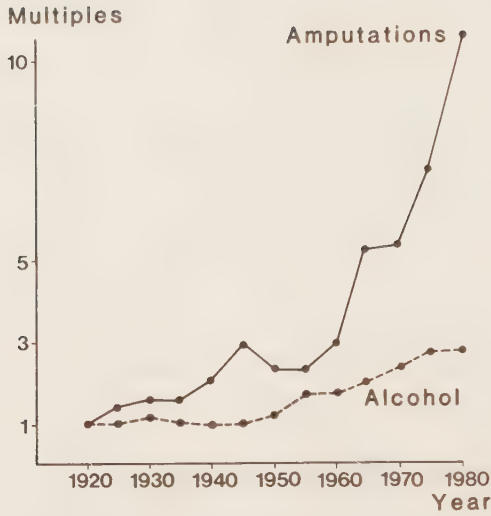


Fig. 5. Amputations and alcohol in Sweden 1920-1980.

Statistical analysis was made with corrected χ^2 when compared to control material and with classical analysis of variance in age comparisons.

RESULTS

Among the 188 studied amputees 100 were men (53 per cent). Eightyfive either were or had been daily smokers, 61 had a concomitant diabetes. The mean age at amputation among males were 75.6 years and among females 78.9. The division of the material into very old amputees (80 years or more), smokers and diabetics is shown in Venn diagram (Fig 6). Due to different smoking habits between the sexes the material was divided into males and females. Among the 100 male amputees 75 were or had been daily smokers, 29 had diabetes and 38 were 80 years or older. Only 5 amputations had been performed in males being neither smokers, diabetics, or at least 80 years (Fig. 7). Among the 88 female amputees 10 were or had been daily smokers, 32 had diabetes and 46 were at least 80. Only 18 amputations had been performed in females being neither smokers, diabetics, or at least 80

(Fig. 8). Among the 23 amputees falling outside the subsets of smokers, diabetics or at least 80, the median age was 76 years (Range 54-79). The youngest out of four men was 54 years old and had a rheumatoid arthritis with vasculitis. In 12 cases the amputation was caused by embolism.

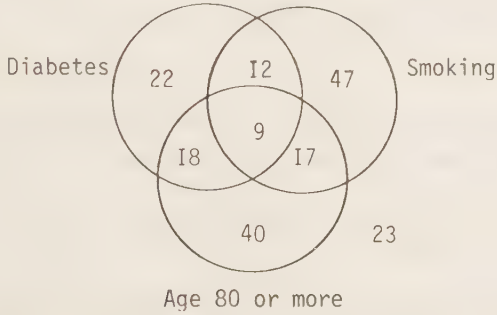


Fig. 6. Age, diabetes and smoking as concomitant factors among 188 amputees, both sexes.

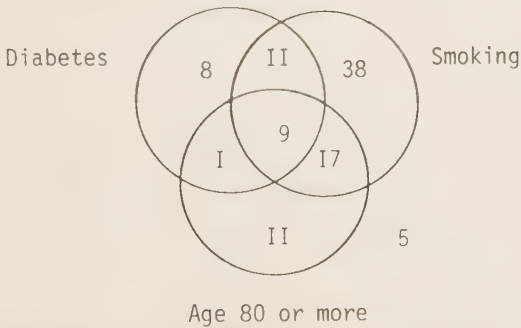


Fig. 7. Age, diabetes and smoking as concomitant factors among 100 male amputees.

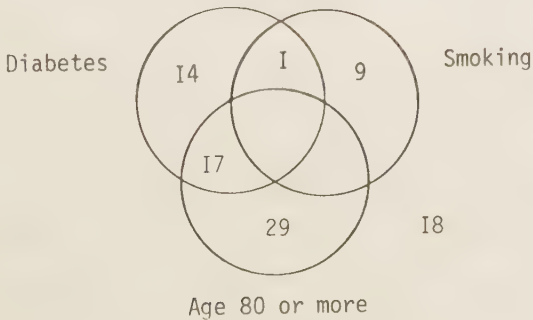


Fig. 8. Age, diabetes and smoking as concomitant factors among 88 female amputees.

As diabetes and smoking might contribute to vascular disease each was isolated. Current smokers were overrepresented among non diabetic amputees. A χ^2 -test showed that smokers were overrepresented with $p=.002$ for all and males but not for females compared to the age and sex matched control material. (Table 1 + 2)

Table 1. Smoking habits and diabetes among male amputees compared to matched controls and to hip fracture patients.

Smoking History	Amputees		Controls		Hip fractures	
	Non Dia-betics	Diabetics	Non Dia-betics	Diabetics	Non Dia-betics	Diabetics
Never smoked	16	9	14	-	16	2
Ex smokers	18	12	27	3	5	-
Light smokers	20	4	7	-	3	1
Heavy smokers	17	4	5	-	5	-
Total	71	29	53	3	29	3

Table 2. Smoking habits and diabetes among female amputees compared to matched controls and to hip fracture patients.

Smoking History	Amputees		Controls		Hip fractures	
	Non Dia-betics	Diabetics	Non Dia-betics	Diabetics	Non Dia-betics	Diabetics
Never smoked	47	31	35	1	78	8
Ex smokers	2	-	1	-	4	-
Light smokers	3	-	1	-	5	-
Heavy smokers	4	1	-	-	1	-
Total	56	32	37	1	88	8

Smoking also affects the age at amputation. Among the non diabetic amputees there was a lower mean age at amputation than among those smoking. The consumption of pipe tobacco was transformed into the corresponding number of cigarettes. Snuffers were judged as non smokers. Table 3 shows the mean age in men at amputation according to smoking habits, the median age being 83 in non smokers and 75 in all that had been smokers. The same calculation is made in female amputees (Table 4). The median age being 82 in non smokers and 66 in all that had been smokers. Increase in smoking lowered the age at amputation in men ($p<.001$) and in women ($p<.001$).

The role of diabetes leading to amputation is clear ($p<.001$) from Tables 1 and 2. The mean time from diagnosis to amputation was 13 years.

Table 3. Age at amputation and smoking habits among non-diabetic males.

Smoking habits	Number of amputees	Mean age	Range
Non smokers	16	80.9	54-91
Ex smokers	18	76.9	64-84
Light smokers	20	77.2	62-94
Heavy smokers	17	67.6	46-89

Table 4. Age at amputation and smoking habits among non diabetic women.

Smoking habits	Number of amputees	Mean age	Range
Non smokers	47	82.9	69-98
Ex smokers + Light smokers]	5	69.4	66-79
Heavy smokers	4	57.0	48-71

The effect on age at amputation of a concomitant diabetes mellitus can be studied in the same way by excluding all smokers. The mean age at amputation among non smoking, non diabetic men was 81 (Median 83) and among the non-smoking diabetics 72 (Median 69) years. The mean age at amputation in non smoking, non diabetic women was 83 (Median 82) years and for the non smoking diabetics 78 (Median 82).

The mean age in non smoking diabetic males was 72.0 (Median 69) years and in all that had been smokers 76.4 (Median 79). The mean age in diabetic men treated with insulin injections was 70.4 years and in those treated with oral drugs 79.5.

DISCUSSION

With increasing age vascular degenerative changes develop (Auerbach 1968) and intermittent claudication becomes more frequent (Kannel and Shurtleff 1973) as does the first admission due to peripheral arterial insufficiency (Tibell 1971). The Framingham study suggests that the incidence of intermittent claudication were comparable between sexes when women were 10 years older than men (Kannel and Shurtleff 1973) and in this study the difference was 3.3 years. In this study 84 out of 188 patients were at least 80 years old and mean age in non smoking non diabetic males 80.9, in females 82.9 respectively.

Among the 188 amputees 32 per cent had diabetes. The prevalence of diabetes mellitus (Schersten 1980) in the area was ranging from 0.9% in the 40-49 year group to 9% in the group 80 or more. Diabetes was far more common among amputees than in the population. The prevalence of diabetes mellitus seems to rise in Sweden. In a nearby county 0.5 per cent were diabetics (Silver 1958) compared to the latest study performed in a part of the hospital area

1.6 per cent (Schersten 1980). In the control material 4 of 94 were diabetics. This means that more than one third of the amputations occur in this small part of the population. Patients with juvenile diabetes mellitus with peripheral vascular disease below the age of 60 are uncommon (Oakley 1955) and so in series of amputees (Goldner 1960). In this series three of the 61 diabetics were below 60 and all three were smokers.

Diabetics are younger at amputation in most studies (Hansson 1964, Hierton 1973 and Christensen 1976). On the other hand Otteman (1965) found that the diabetic patients were four years older in average among 323 leg and foot amputees. In this study diabetic men were 9 years younger and women 5 years younger than the non diabetics excluding all smokers.

The proportion of smokers between male and female amputees was different. The explanation for this is that women seldom started a smoking habit in this age group. This also affects the mean age at amputation in smokers and non smokers. Daily smoking of more than 10 cigarettes reduced the mean age at amputation 13 years in men and 26 years in women, which is affected by the higher occurrence of smoking in younger women. There are now more young smoking women than men (Baroll and Ramström 1980) which might lead to a future increase in female amputations. In a study of the relation between aortic arteriosclerosis and the use of cigarettes and alcohol smoking habits of females above the age of 70 is mentioned. Six per cent smoked less than 10 cigarettes per day and five per cent more than 10 cigarettes per day. No significant relation between arteriosclerosis and alcohol was found (Sacket et al 1961). In that outopsy study "a graded and statistically significant increase in the severity of aortic arteriosclerosis was found with increasing use of cigarettes measured by both intensity and duration".

Alcohol consumption affects mortality and has a U-shaped curve, giving lowest mortality in the moderate drinkers. Additionally in all groups of alcohol consumption a higher death risk was found in smokers than in non smokers (Marmoth 1981). This excess mortality may partly explain the few amputated smokers 80 years or older (Fig 6, 7 and 8).

It is known that cigarette smoking affects the course of disease of peripheral arteries (Juergens et al 1960, Holmes et al 1979). Smoking of cigarettes positively correlated with a higher incidence of intermittent claudication. Heavy smokers have 3 times the risk of non smokers to develop intermittent claudication. The arteriosclerotic process occurring in the heart, head and peripheral arteries in the legs appear to be pathologically identical (Kannel and Shurtleff 1973). There was a significant overrepresentation of current smokers among the amputees compared to their controls matched according to age and sex in men. Previous smokers however did not show any higher risk in this study and smoking cessation seems to halt vascular changes (Janzon 1974).

Arteriosclerosis is a multifactorial disease (Böttiger and Carlsson 1980). The demonstration of changes in some environmental factors like cars and alcohol consumption only illustrates some large changes that have occurred contemporarily but do not implicate any causative mechanism. Earlier the young cigarette smoking male with occlusive vasculitis without arteriosclerosis has under the name of Bùrgers disease been identified (Mc Kusich et al 1962). Here a larger group with arteriosclerosis leading to amputation is correlated to smoking and it is suggested that smoking as well as diabetes should be noted as specific subsets of arterial occlusive disease among amputation patients. This might possible lead to increased cessation of smoking even at amputation and thereby increased chances of avoiding

further amputations. Janzon (1974) among others has shown this is so at vascular surgery. Until the causes have been further clarified it is suggested that besides diabetes, smoking and age 80 or more should be noted.

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III

A CLINICAL STANDARD OF STUMP MEASUREMENT AND CLASSIFICATION IN LOWER LIMB AMPUTEES

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SUMMARY

The dimensions and healing was followed in 93 consecutive below-knee stumps and based on these observations a standard formula of stump classification was constructed and discussed at the ISPO Meeting in Bologna 1980.

Muscular atrophy and redistribution of oedema caused a mean reduction of calculated arbitrary stump volume of about 7% during the first 12 post-operative weeks but the distal circumferential measures ranged between 7 centimeters reduction and 5 centimeters increase.

The classification formula was tested at 135 examinations of residual lower limbs in 86 patients with 96 stumps in Lund. A new proportional definition of stump length was used. Eighty per cent were ordinary in length and shape. Ten of 59 were pointed before one year compared to 12 of 42 after more than one year. Pain was a problem in 20%. Scar problems are common early but other skin damages increase by time. Skin problems are separated according to causative mechanisms, i.e. pressure, suction, infection and allergy. One third of below-knee stumps had unhealed wound or damaged skin. Surgical correction was indicated in 2% and prosthetic correction in 7%. Prosthetic correction seemed more often needed in below-knee stumps and surgical in above-knee stumps.

INTRODUCTION

The detailed condition of an amputation stump is little discussed in literature, although there is generally an unspoken concept of stumps being bad or good ones. The increased number of amputations among elderly with occlusive arterial disease increases the need for objective evaluation of stumps because old patients are less often well informed themselves. To structurize the basic clinical parameters of stumps we have considered the alternatives of dimensions to utilize and created a test for of basic characteristics. At the last world meeting of the International Society of Prosthetics and Orthotics (ISPO) in Bologna, October 1980, a special Round Table was devoted to such discussions with Sydney Fishman, New York, William Wagner, Los Angeles, P.A. Isherwood,

Roehampton, S. Goldbrandsen, San Diego, P. Renström, Gothenburg, M. Wall, Uppsala, Sweden and the authors. At this meeting the test form was corrected and accepted to be used in clinical trial focusing on the stump itself. Function, however, also depends on the general condition of the patient and the type and condition of the prosthesis and finally the fit and training level that has been achieved.

This paper presents the basic parameters studied in the preparatory work and the use of the standard form in a consecutive series of lower limb amputees. By this systematic examination important qualities of major amputation stumps should be identified, increasing the possibilities to analyse problems and correct malfunction.

MATERIAL AND METHODS

In part one measurements were made repeatedly during the first 12 weeks after amputation in a consecutive series of 93 below knee stumps. All patients were amputated with the sagittal technique (Persson 1974) at the Department of Orthopaedic Surgery in Lund. They were kept in plaster of Paris for 2 weeks and had stitches removed at 3 weeks. The measurements were made at 2, 3, 4, 6 and 12 weeks after amputation recording proximal stump circumference with the knee at 60° flexion, distal stump circumference, and length of stump from distal end of the soft tissues to the medial joint space of the knee. Simultaneously the healing was recorded. The measurements intended to describe size, shape and atrophy allowing classification of stumps into cylindrical, conical or club-shaped, which determines type of suspension, as well as short, ordinary or long, which determines the lever arm of movements. It also allowed calculation of volume changes, which determines changes of socket fitting.

In part two the ISPO standard form was used in a consecutive series of 135 stump examinations at the prosthetic clinic January - September 1981 (Fig. 1). During this time 86 patients with 96 stumps were followed. Two stumps were measured four times, five three times and 23 two times. Fifty-eight per cent of the patients were males and 85 per cent had been amputated within the last five years. The median age was 72.5, range 10-94 years.

Fig. 1

CLINICAL STANDARD OF MEASUREMENT AND CLASSIFICATION OF AMPUTATION STUMPS I S P O 1982 International Society for Prosthetics and Orthotics, Standing Committee on Research		Name and address of patient:	
General condition of patient:		Indication of amputation:	Date of amputation
☐ Highly active ☐ Average ☐ Little walker		☐ Ischemia ☐ Trauma ☐ Tumor ☐ Other	_____
BASIC PARAMETERS OF STUMPS		Mark level of amputation on figure:	
1. Length 2. Shape 3. Scar 4. Skin Inspection		 Pelvic amputation (Hemipelvectomi) Hip " (Disarticulation) Femoral " (AK) Knee " (TK) Crural " (BK) Ankle " (Syme etc)	
5. Solidity 6. End 7. Mobility 8. Pain Palpation		Side: ☐ Rt ☐ Lt	
1. Length of stump ☐ Ordinary: Length=(1-2)x Breadth ☐ Short: Length < Breadth ☐ Long: Length > 2 x Breadth		4. Skin of stump ☐ Undamaged ☐ Deep wrinkle <u>Pressure</u> ☐ Abrasion ☐ Ulcer ☐ Blister ☐ Epidermoid cyst <u>Suction</u> ☐ Suction discoloration ☐ Verrucous hyperplasia <u>Infection</u> ☐ Folliculitis ☐ Infected ulcer <u>Allergy</u> ☐ Eczema	
2. Shape of stump ☐ Cylindrical (ordinary) ☐ Conical ☐ Club-shaped			
3. Scar of stump ☐ Well healed ☐ Unhealed (....x....cm) ☐ Bone exposed ☐ Adherent		6. End of stump ☐ Rounded - well protected bone ☐ Pointed - poorly protected bone	
5. Solidity of stump ☐ Firm (ordinary) ☐ Soft (fatty or loose muscle) ☐ Oedematous		8. Pain of stump ☐ None or little ☐ Significant local ☐ Significant diffuse	
7. Mobility of stump in proximal joint ☐ Normal ☐ Limited extension.....degrees ☐ Limited flexiondegrees		10. Maximal end-weight-bearing on a scale ☐ With naked stumpkilogram ☐ With prosthesis on.....kilogram ☐ Body-weightkilogram	
9. Phantom pain ☐ None ☐ Some ☐ Severe		12. Date and signature:	
11. Summary ☐ No correction indicated ☐ Special problems noted above ☐ Prosthetic correction indicated ☐ Surgical " " ☐ Prosthesis prescribed ☐ No prosthesis indicated		_____	

Classification was made of general condition, indication, level, size, shape, scar, skin, solidity, end of stump, mobility in proximal joint, pain of stump and phantom pain. The definitions of the different classes of the parameters is explained in Figure 1 regarding proportional length, shape, scar, skin and mobility. Regarding solidity, end of stump, stump pain and phantom pain the limits between different classes were not defined exactly. Age, sex, side, date of amputation and date of examination were recorded and it was summarized whether correction was indicated technically or surgically.

RESULTS

In part one the 93 new below-knee residual limbs had a median length of 16 cm, range 10-25 (Fig. 2). The proximal circumference at the basis of the stump was recalculated to diameter and used as a measure of breadth describing the length to breadth proportion (Fig. 3). The mean quotient was 1.7 with the range from 0.9 - 2.5. In this material one stump was classified as short and 10 stumps as long (Fig. 3).

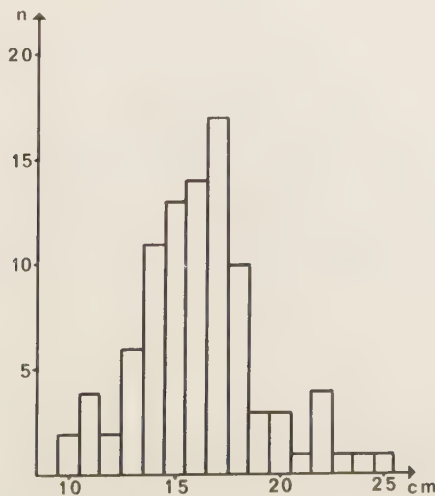


Fig. 2. Length of below-knee stumps.

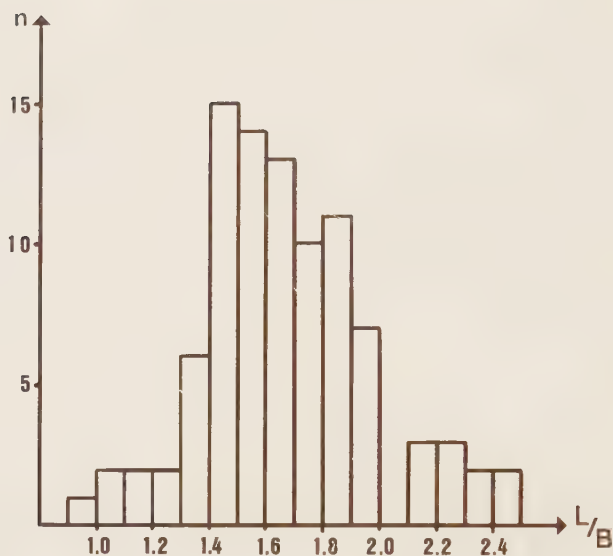


Fig. 3. Proportional length of below-knee amputation stumps.

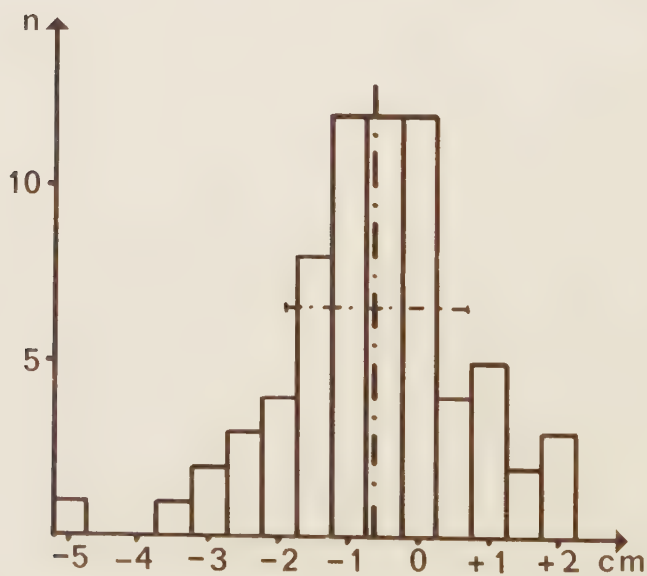


Fig. 4. Change of proximal circumference between 2 and 3 weeks in below-knee stumps. Dotted cross indicates mean value and standard deviation.

The proximal circumferential measurements (Figs. 4 and 5) showed the changes between 2 and 3 weeks and 2 and 12 weeks, respectively. Less than 1 cm of reduction occurred from 2 to 3 weeks in mean value and less than 2 cm between 2 and 12 weeks. Similarly the distal circumferential measurements (Figs. 6 and 7) showed about 1.5 cm of reduction from 2 to 3 weeks, and about 2.0 cm between 2 and 12 weeks, but in the latter case with range from maximally 7 cm reduction to 5 cm increased circumference distally. The mean quotient between proximal and distal circumference was at two weeks 1.01 (SD 0.07) and at 12 weeks 1.04 (SD 0.09) indicating a tendency towards a more pointed stump.

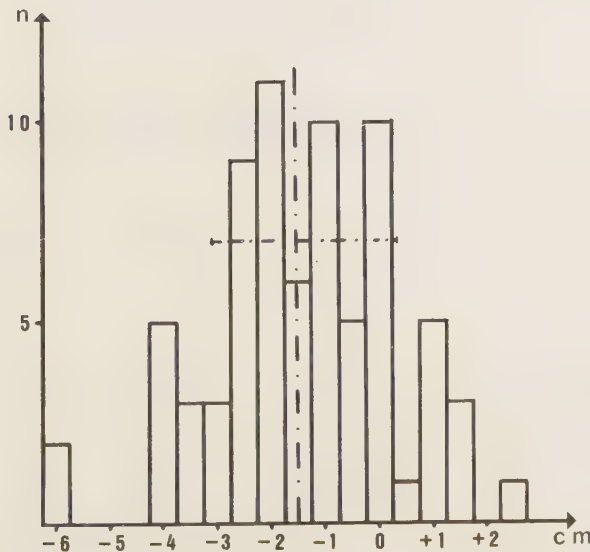


Fig. 5. Change in proximal circumference between 2 and 12 weeks in below-knee stumps. Dotted cross indicates mean value and standard deviation.

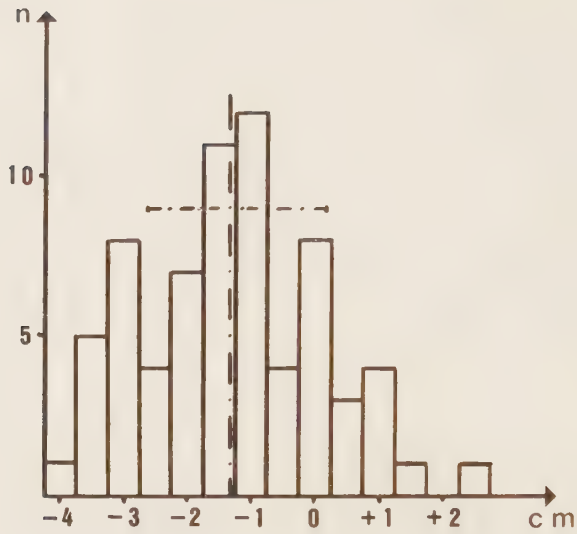


Fig. 6. Change in distal circumference between 2 and 3 weeks in below-knee stumps. Dotted cross indicates mean value and standard deviation.

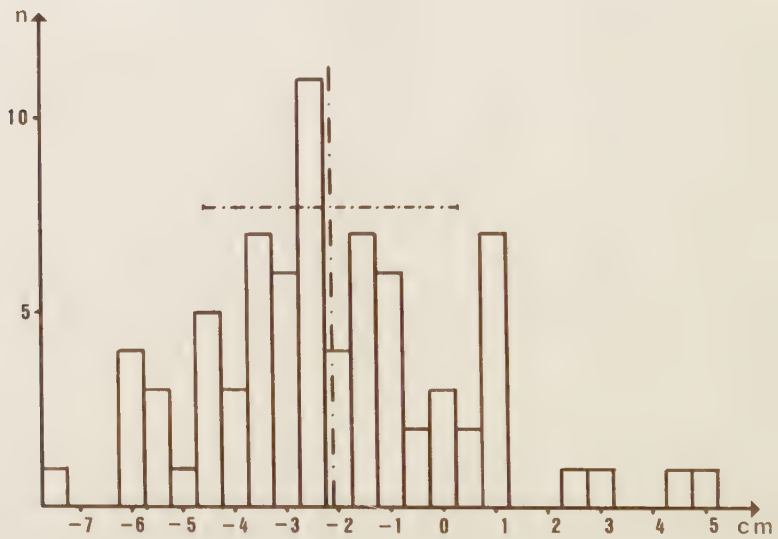


Fig. 7. Change in distal circumference between 2 and 12 weeks in below-knee stumps. Dotted cross indicates mean value and standard deviation.

The length of the stump should be constant as bone does not shrink but shrinking soft tissues may cause reduction and acquired oedema may cause decreased length. We found an average shortening of 0.5 cm (Fig. 8).

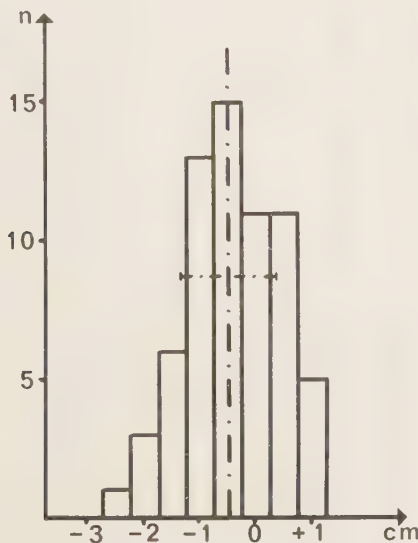


Fig. 8. Change in measured length of below-knee stumps between 2 and 12 weeks. Dotted cross indicates mean value and standard deviation.

Using proximal and distal circumferential measurements and the length we arbitrarily calculated a volume at 2, 4, 6 and 12 weeks after amputation with the stump represented as a cut cone. Fig. 9 describes this volume at 2 weeks after amputation with a mean value of 1.3 liters ranging from 0.5 - 2.1 liters (SD 0.3). This calculated volumes by time 2, 4, 6 and 12 weeks after amputation showed a gradual decrease with the most significant reduction from 2 - 4 weeks and with a total reduction during the first 3 months of about 7 per cent (Fig. 10).

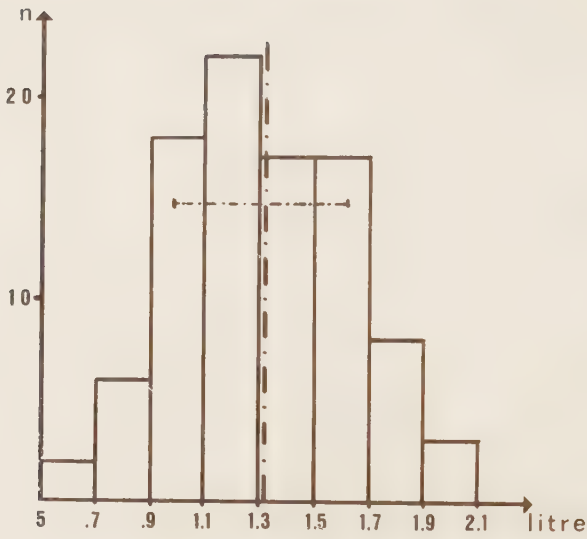


Fig. 9. Arbitrary volume of calculated cut cone representing below-knee stump volumes.

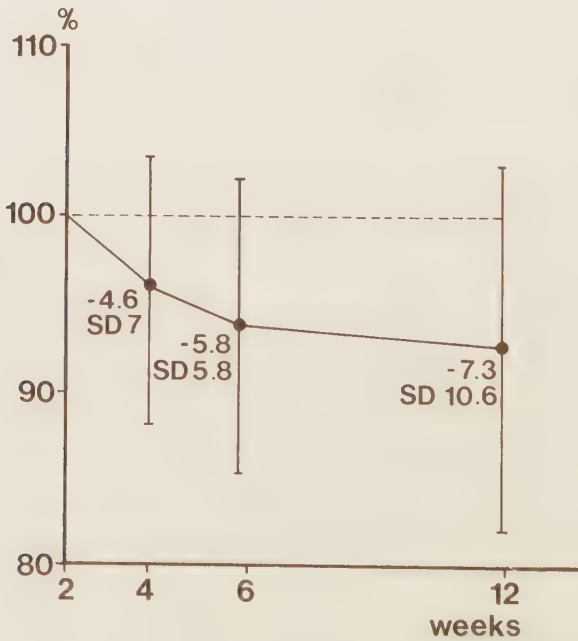


Fig. 10. Change in calculated below-knee stumps volumes between 2 and 12 weeks. Mean values and standard deviation.

Stumps that were between 1 and 1.5 longer than the breadth had a non significant lower proportion of unhealed wounds than the longer stumps (Fig. 11).

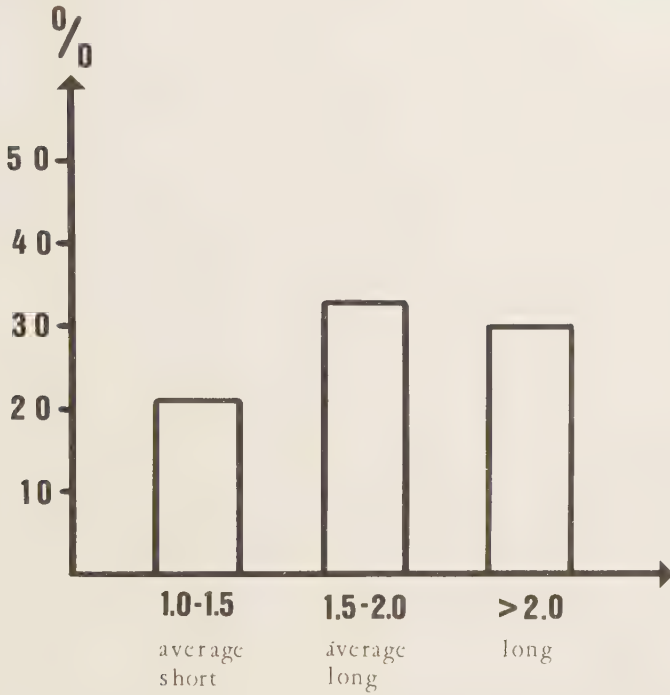


Fig. 11. Proportion of unhealed wounds of below-knee stumps in three groups of proportional length.

In part two the result of using the ISPO classification form showed that some classifications are totally depending upon level. Lower limb stumps created by joint disarticulation, for instance, all five were long and club-shaped stumps with insignificant stump pain and phantom pain. Only the below-knee level, however, contained enough patients to make statistical analysis reasonable, 116 of all 135 measurements were below-knee, 12 in above-knee and the residual 7 in disarticulations at hip, knee and ankle levels. Eighty-two per cent of the patients had been amputated for arterial occlusive disease with or without diabetes.

In the below-knee group the proportion of different characteristics were as follows: Highly active walker 0.20, average 0.58 and little active 0.35. Ischemia was the indication in 0.89. The stump length was ordinary in 0.81, short in 0.13 and long in 0.06. The shape was cylindrical in 0.80, conical in 0.19 and club-shaped in 0.01. The scar was well healed in 0.77 compared to 11 of 12 in the above-knee group. It was adherent in 0.09 among below-knee and this proportion was the same in above-knee patients.

The skin was undamaged in 0.71 of all without difference between above and below knee levels (Table 1) but stumps older than 3 years had a significantly higher proportion of skin damage ($p < 0.005$).

Table 1. Skin condition. Number with damage among above and below-knee stumps.

Condition	AK only	BK only
Undamaged	9	81
Abrasion	1	8
Ulcer	-	5
Infected ulcer	-	5
Epidermoid cyst	1	2
Suction discoloration	-	4
Blister	-	1
Verrucous hyperplasia	-	1
Folliculitis	1	1
Eczema	-	1
Total	12	109

Above-knee stumps were soft in 3 of 12 compared to 16 of 116 in below-knee and they were pointed in 2 of 12 compared to 25 of 110 below-knee stumps. Mobility was registered as normal in 88 of 116 in the below-knee group and 23 of 116 had limited extension of at least 10 degrees.

There was no significant difference when the material was separated according to sex. Stump pain was equally a problem in one fifth and when separated according to level 0.18 of below-knee amputees had stump pain and 0.21 had phantom pain. There was no significant change in stump pain or phantom pain when the material was separated into four different time intervals at 6, 12 and 36 months.

The end of below-knee stumps had a tendency to be more pointed with time. Ten of 59 (0.17) were pointed being less than one year, compared to 12 of 42 (0.29) after more than one year.

In summary, correction was found to be indicated equally in 7-8% of above and below-knee stumps concerning prosthetic changes and in 3 compared to 1% concerning surgical changes.

DISCUSSION

There are few publications on general conditions of amputation stumps. Residual limbs are left to the orthopaedic technicians to fit and few reports describe the encountered problems. Staros (1963), Hansson (1964), Eriksson (1965), Burgess et al. (1971), James and Öberg (1973), Murdoch (1975), Grevsten and Stålberg (1976), and Baumgartner and Langlotz (1980) are describing different aspects of rehabilitation problems. Weiss, Fishman and Krausse (1971) made a thorough analysis of 100 lower limb amputees considering psychological and pain aspects but they did not study other parameters like shape, solidity, strength or range of motion. Persson and Brunk (1974) found that strength seldom was a limit for walking ability.

Renström (1981) examined 63 below-knee amputees and found 18% with phantom pain corresponding to our figure. Among 58 stumps he found a mean length of 14 cm compared to our 16 cm. To the circumferential

measurements he made on thigh and on middle of stump we have no corresponding observations. Thirty-six per cent of this stumps had wounds or erosions compared to our 14% unhealed below-knee stumps and 30% with other skin damages. The measurements of volume changes due to oedema and muscle atrophy reported by Renström using computer tomography and ours using a tape has no exact correspondence. Renström measured 5 patients 1-12 months after amputation and found a decrease of 25% during the first 4 months compared to our 8% during the first 12 weeks using tape measurements and calculation of volume. The circumference of the stump decreased with 5% during the first 4 months and another 3% at 12 months in Renström's material which possibly corresponds to our observations. Renström, however, also took into consideration the increase in circumference of the non-amputated leg simultaneously being 3% at 4 months and 6% at 12 months. Renström also made another interesting observation using dator tomography (CT-scanning). The attenuation in Houndsfield units was significantly lower in the stump after amputation compared to the non-amputated leg. Dator tomographic examination of amputation stumps showed decreased skeletal and soft tissue density also in studies published by Hübner et al. (1981). The volume observations made by Fishman (1971), Goldbrandsen (1980) and Renström (1981) describe volume fluctuations in mature stumps which we have not studied in this paper. It seems to be about 5% in many cases and can be a great trouble of prosthetic fitting. This is illustrated by Goldie's et al. (1974) liquid pad and Isherwood's (1974) adjusting pad. Increased distal stump circumference was seen in active patients who had been forced to inactivity by their disease and could reconstitute their muscular mass by walking postoperatively.

The definition of long and short stumps used in this text is new. Earlier classifications have utilized the length of stump as an absolute measure in centimeters. To consider the difference between tall and short stature a relative measure has also been used in per cent of unamputated side. Some patients, however, have very thick limbs relatively and a certain relative length compared to the unamputated side does not explain the problems with fitting a socket. Therefore, a proportional measure considering the diameter of the stump has been used by us. For this the breadth of the stump at the basis has been noted. This measure is much easier appreciated than a measurement of circumference and very quick to estimate (Fig. 1). This pragmatic method of differentiation of stumps

into short, long and ordinary ones is easy in practical clinical judgement. Stumps shorter than the breadth are felt to be short and those longer than twice the breadth are felt to be long. This impression of length is the same whether it is a below-knee or an above-knee amputee and probably about the same also on the upper extremity.

In the clinical standard of measurement and classification the condition of the scar has been separated from the condition of the skin. It was felt that the healing of the amputation wound could be simply classified as healed, unhealed or adherent, which is a result of secondary healing when skin adheres to bone. If unhealed the length and breadth of the defect should be noted to follow the healing. The skin of the stump otherwise is either undamaged or damaged by mechanical factors like pressure or shearing of the socket. This is listed separately from suction discoloration to chronic verrucous hyperplasia. Mechanical or hydraulic effects mentioned can be separated from skin damages where infection contributes like folliculitis and infected ulcers. If pressure, suction or infection is not the causative agent to damage it might be hypersensitivity reactions to materials simply labelled eczema. These different categories of skin lesions of stumps has been especially dealt with by Levy (1980). We found that scar problems were common during the early period and the other skin problems increased by time (Table 1).

Most aspects found on inspection and palpation have been taken into consideration and simplified. One parameter has been omitted. That is strength. Muscular atrophy, shortness of lever arms, softness of stumps and pain altogether make it difficult to record strength of stumps, and it is our belief that strength is of little importance in walking.

This study has not included the patient with prosthesis. Judged by the stump a prosthetic correction was considered to be indicated in seven per cent and a surgical correction in two per cent. Surgical correction was more often indicated in above-knee stumps and prosthetic correction more often in below-knee stumps. In thirty-nine per cent special aberrations had been noted signifying that all was not well. Important parameters influence on selection of socket or type of suspension, or on components, alignment and training of a patient. These simple criterias of ordinary and special stumps and the systematic separation of skin problems is helpful in finding a cure.

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IV

MEASUREMENT OF MAXIMAL END-WEIGHT-BEARING IN LOWER LIMB AMPUTEES

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ABSTRACT

Modern types of sockets for lower limb amputees utilize total contact and distribute some weight on the stump end. Its tolerance to bear weight varies, however, and is better after joint disarticulation but systematic measures have been missing. Different levels, indications, shapes etc were analysed with 102 measurements in 69 patients. The maximal-end-weight-bearing measured on a scale with naked stump was much lower after trans-medullar amputations than after disarticulations. Men had a mean tolerance above 15 but women less than 10 kilograms. There was a positive correlation to body weight. Diabetics tolerated significantly more and patients with phantom pain more than patients with stump pain. Within each category of stumps the range of maximal end-weight-bearing was large. Among all below-knee amputees the tolerance was between 2 and 55 kilograms or 3 and 79 per cent of body weight. Pointed stumps statistically tolerated about as much as rounded ones and the variability of contact surface was not measured as its sensitivity to pain must be unevenly distributed. It is concluded that this simplified method is helpful to analyse pain and to modify end-weight-bearing more individually.

INTRODUCTION

It is well known that knee disarticulation and Syme's amputation create stumps of high functional value. This is ascribed to the long lever arm for the movement of the prosthesis, to the reliable suspension due to the club shape of the stump and to the high end-weight-bearing capacity due to the rounded bone end and its large surface (Hornby & Harris, 1975). To create an increased surface of the bone end at a transmedullary amputation Swanson (1973) has tried a silastic plug implanted into the marrow cavity to cover the end of bone. Dederich (1963) and others have suggested osteoplasty to bridge between fibula and tibia at below-knee amputation to enlarge and stabilize the end of bone. Foort (1981) has asked for attempts using the femoral condyles or similar bone trimmed and put back at the amputation level to create such an increased breadth of the surface to improve end weight-bearing

Older types of artificial limbs were either created for end bearing or for proximal bearing (hanging stumps) but most modern types of sockets distribute weight-bearing over the total stump in spite of that some parts

are given extra load. It is therefore not well-known to what extent stumps tolerate end weight-bearing. Renström (1981) in a series of below-knee amputees, examined maximal end loading capacity using an ordinary weighting scale. Hornby and Harris (1975) examined a series of Syme's amputations also using a scale but combining the recorded total maximal end weight-bearing with readings from a transducer pad, put into the bottom of the socket and relating to body weight what they called maximal end-weight-bearing capacity.

This paper presents a study of maximal end weight-bearing capacity of the residual limbs after lower limb amputation at different levels with the intention to find out how such values differ and if possibly this can be used in future at fabrication of the total contact socket or in analysis of pain.

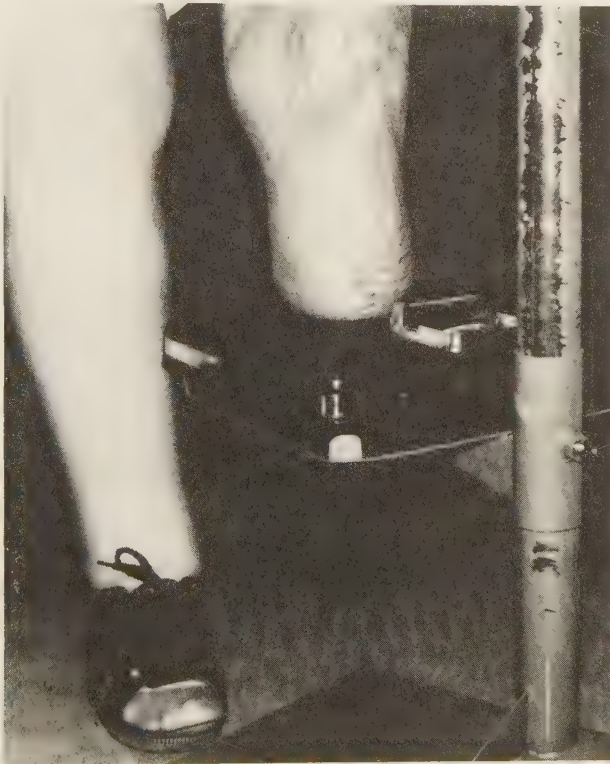


Fig. 1. Weighting scale mounted on adjustable table to measure maximal end-weight-bearing capacity of amputation stumps.

MATERIAL AND METHOD

During 1981 we made 102 measurements in 69 patients of which nine were bilateral. Repeated measurements were made in 24 cases who had been seen with an interval between 1 and 9 months.

The method to measure the maximal end weight-bearing capacity is described in Fig. 1. A weighting scale of spring type (EKS, 0-120 kg, Holland) constructed for ordinary body weight measurements was mounted on a table. This was adjustable to a height fitting the individual when standing allowing comfortable pressure with the stump on the scale. The patient watched the scale how much weight he could put on gradually for a few seconds. This was repeated two or three times and a recording was noted which the patient had been able to reproduce. The top of the scale had a cover with a soft plastic material, 3 mm thick. When the measurements in 10 below-knee amputees were repeated with a hard wooden surface there was no change in tolerance however. Simultaneously basic notes were collected concerning age, sex, body weight, indication of amputation including diabetes, level, time after amputation, general activity, shape of stump and phantom and stump pain problems.

RESULTS

The mean age of the examined population was 67 years, the below-knee male group was 68 (SD 15) and the below-knee female group 76 (SD 11) years. The mean body weight was 64 kilograms, the below-knee males 70 (SD 10.6) and the below-knee female 57 (SD 11.4). The mean maximal end-weight-bearing capacity (MEW) of the entire population was 13 (SD 12.0) for the below-knee male group 13.3 (SD 10.7) and the below-knee female 7.9 (SD 5.3) kilograms.

Separated into different levels of amputation Figs. 2-3 describe the recorded end weight-bearing capacities. Amputation through joints (hip, knee and ankle) had a much higher end-weight-bearing tolerance than trans-medullary (AK and BK) amputations. Above-knee amputees tolerated 13.7 kilograms compared to below knee 11. Ischemic below knee amputees had a mean of 10.7 (SD 9.0) compared to other indications 13.9 (SD 10.9) kilograms.

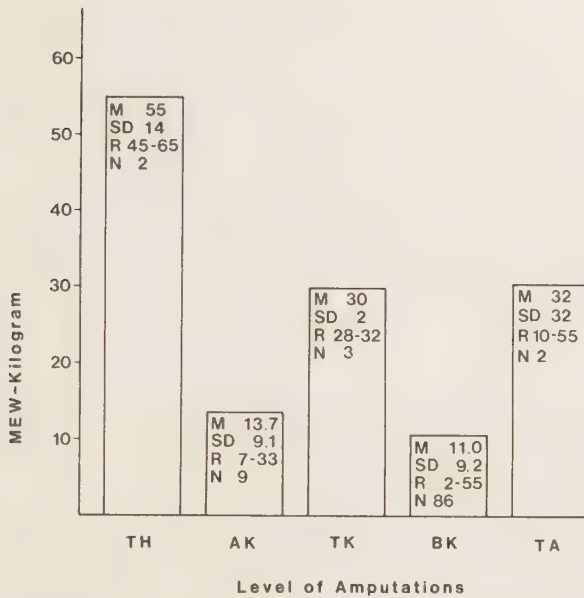


Fig. 2. Maximal end-weight-bearing (MEW) and level of amputation: TH = through hip, AK = above knee, TK = through knee, BK = below knee and TA = through ankle. M = mean, SD = standard deviation, R = range, N = number.

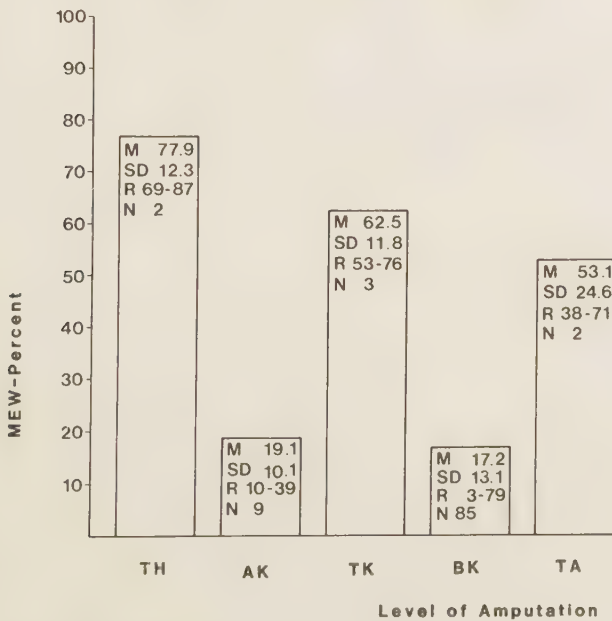


Fig. 3. Maximal end-weight-bearing (MEW) in per cent of body weight and level of amputation.

There was a significantly higher MEW-value in patients with a higher body weight (Fig. 4). Tested on the entire population there was no increase by time after amputation ($p = 0.45$). When looking at the below-knee level only there was still an increased MEW-value with increasing body weight ($p = 0.01$) but none with increasing postoperative time ($p = 0.47$). The male population had a significantly higher value than the female, (15.7 versus 9.4 kilograms). Among below-knee amputees active walkers tolerated more than little active walkers.

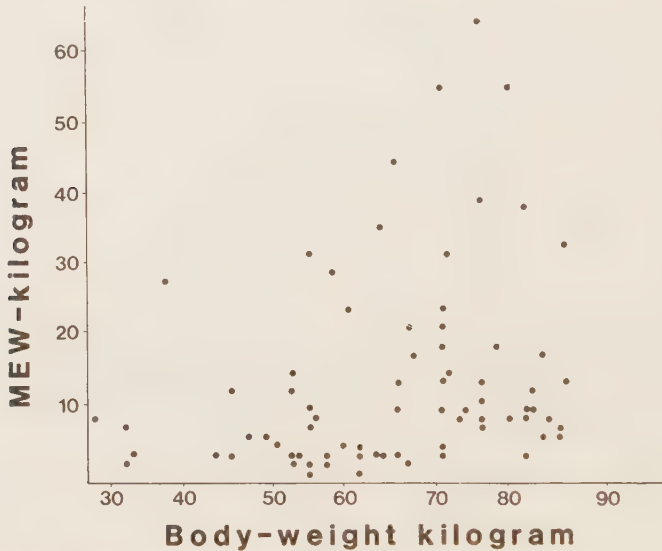


Fig. 4. Maximal end-weight-bearing (MEW) and body weight in below knee amputees. $N = 101$, $p = 0.01$, $y = 0.3 + 0.2x$.

It was noted that some patients with very high MEW-values after below knee amputations were diabetic and when we tested for this correlation we found for the below-knee level among diabetics 14.3 (SD 13.5) and non-diabetics (SD 6.2) kilograms (Fig. 5). This difference was the same when tested as absolute values (MEW-kilograms) or in relation to body weight (MEW-per cent). The lack of protective sensibility of diabetic patients could be expected to cause an increased number of patients with skin damage. In this material, however, there was no such difference with one fourth of the patients with skin damage in both groups. Also concerning pain of stump and phantom pain there was no correlation to diabetes.

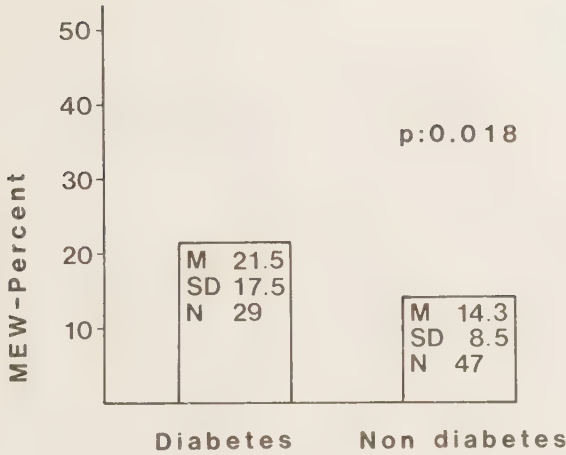


Fig. 5. Maximal end-weight-bearing (MEW) in per cent of body weight among BK amputees for ischemia with and without diabetes.

The maximal end-weight-bearing (MEW) is limited by tolerance of pain during the procedure. Patients with stump pain or phantom pain were separately analysed. Pain of stump was correlated to significantly lower MEW-value (Fig. 6) but phantom pain was not (Fig. 7). To a certain extent the shape of the stump end could be correlated to perception of pain at testing MEW-values. There was no such difference between pointed and rounded stumps when analysed on all (Fig. 8) but when tested on stumps older than one year there was such a tendency but not statistically significant.

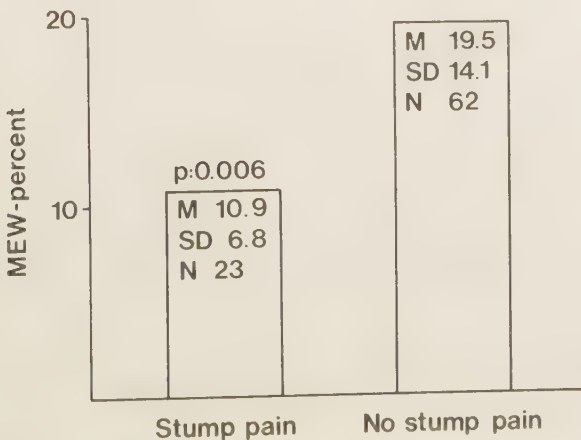


Fig. 6. Maximal end-weight-bearing (MEW) and stump pain in BK amputees.

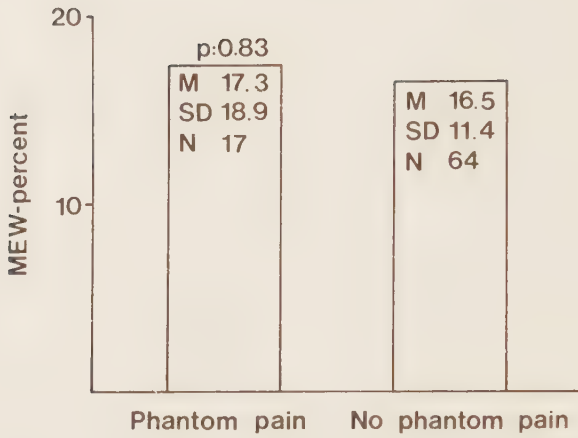


Fig. 7. Maximal end-weight-bearing (MEW) and phantom pain.

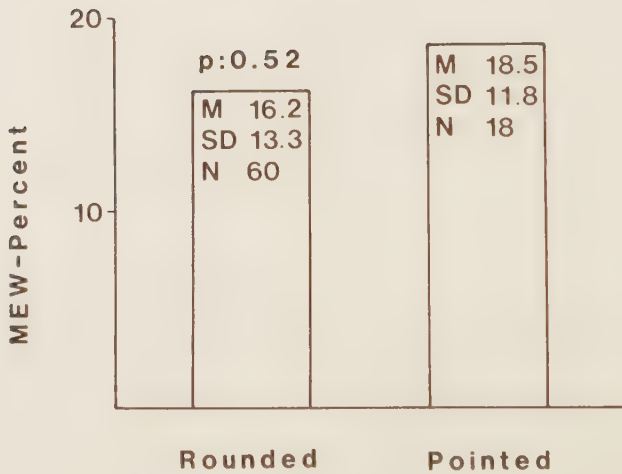


Fig. 8. Maximal end-weight-bearing (MEW) in per cent of body weight in BK amputees with rounded and pointed stump ends.

DISCUSSION

Measurements of mechanical loading of stumps after amputation has not been used often according to literature although weight-bearing capacity is critical for function with prosthesis and decisive for construction of the socket. Baker and Stableforth (1969) found only five of 67 Syme amputations unable to bear full weight on their stumps standing, and Hornby and Harris (1975) found 19 of 68 traumatic Syme patients unable to stand on bare stump. They recorded "end-weight-bearing values" between 28 and 100 per cent of body weight with mean value around 75 per cent and noted that "those who could tolerate full end bearing on their bare stumps did well no matter what type of prosthesis they used".

The positive correlation between increased body-weight and end weight-bearing capacity makes it reasonable to use MEW-values in per cent of body weight (MEW-per cent) rather than absolute values (MEW-kilograms) but we have worked with both units in this study because we believe that the measure in kilograms is easier. Newton is the correct SI-unit for pressure but when comparing to body weight it is pragmatic to retain kilogram for end-weight-bearing.

It seems possible that an enlarged series had proved our tendency that through-knee amputations tolerate more than Syme and that through-hip tolerate more than through-knee and that these joint disarticulations as a group tolerate several times higher end-weight-bearing than trans-medullary levels do (Figs. 2 and 3).

It is highly interesting that diabetics had higher MEW-values though they had not a higher proportion of skin damage. We knew before they have a better healing potential at below-knee amputation (Persson 1974) and that they might have a polyneuropathy which can explain their higher MEW-value. There is no information about how they manage with prosthesis as a group compared to non-diabetic ischemia patients but we know that they are about 4 years younger. It is possible that longstanding diabetes gives higher MEW-values than old-age diabetes but our material did not allow that distinction.

It was expected we should find increased MEW-value with time after amputation. There was such a tendency but insignificant. Our study was not, however, designed well to study this as it should need a series of patients individually followed at regular intervals. Hornby and Harris (1975) state that: "With the passage of time the Syme stumps toughened and became less sensitive" Renström (1981) examined 21 below-knee stumps (19 men, 2 women) 6-90 months postoperatively before and after 10 weeks of muscular training and observed that the loading capacity of the bare stump end increased from 11.9 ± 2.9 (3-35) to 14.5 ± 2.2 (3-40) kilograms as measured on a weighting scale. He did not compare this to any control group without training and the group contained amputees of traumatic, tumorous and ischemic types with and without diabetes. Therefore detailed comparison with our materials is not possible.

Except for Syme and below-knee levels as cited above no reports of maximal end-weight-bearing tolerance have been found in literature. Analysing pain Weiss et al. (1971) measured surface pain and deep pressure sensitivity around the circumference of stumps and found very significant correlation with psychological selfrating criteria. Their findings probably correspond to our low ratings of maximal end-weight-bearing (MEW) in patients with stump pain. They measured around one circle 2.5 cm below the medial tibial plateau or perineum in 44 below and 56 above knee amputees respectively, and compared to the unamputated side. The readings were taken by using a piston rod spring, with the tip one quarter inch square. Deep cutaneous pressure tolerance per square centimeter could thus be recorded ranging from 0 to 20 kg/cm², between 5 and 20 in the best rehabilitated cases. Deep pressure sensitivity had a mean of 4.3 kg/cm² in above-knee patients and 5.7 kg/cm² in below-knee patients (p 0.05). For the entire sample the below-knee stumps were less sensitive but deep sensitivity was the same in below and above-knee stumps among diabetics. No reports are given concerning difference of sensitivity between diabetics and non-diabetics as found in our study. The difference we found between above and below-knee levels was not significant and is contradicted by the tendencies that below-knee stumps had a higher tolerance of load per square inch around a distal circle in the above mentioned study (Weiss et al. 1971).

Older stumps are getting more pointed by atrophy simultaneously as they may become toughened by training. We could not demonstrate different MEW-values between rounded and pointed below knee amputees. Extremely pointed stumps of course must tolerate less total end loading due to the small surface. Theoretically maximal end-weight-bearing should be analysed with account taken to the area of contact but this would make a more elaborate method necessary at the same time as it can not be assumed that the tolerance is evenly distributed at all. The most sensitive part limits the load irrespective of the total contact surface. The lack of correlation between shape of end and MEW-value illustrates this and simple measurement of the maximal end-weight-bearing disregarding the contact area thus is preferred.

The difference we found between patients with stump pain and phantom pain seems highly interesting as an objective method to differentiate pain problems and to refine the socket distribution of pressure at the casting for prosthesis. The total contact socket should distribute weight-bearing differently in different individuals allowing the patient to put at least his body-weight on the artificial limb with a minimum of pain and adverse skin reactions.

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V

THE TOLERANCE OF EARLY WALKING WITH TOTAL CONTACT AMONG BELOW-KNEE AMPUTEES - A RANDOMIZED TEST

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ABSTRACT

Immediate postsurgical limb fitting was introduced by Berlemont and Weiss, but it was found that postoperative plaster shell gave better healing than immediate walking with a prosthesis in amputees with arterial occlusive disease. To reduce the need for repeated changes of socket due to postoperative atrophy and resorption of oedema simple temporary limbs are wanted to postpone casting of individual sockets until the stump is more mature. A randomized study of 95 below-knee amputees was performed with a re-usable temporary one-size prosthesis. It was of endoskeletal type with tube length adjustable. Total contact was created by molding of a thin plastic pillow around the stump. It contained small plastic pellets in parallel connected sections and when air was evacuated it was made rigid. The stump with pillow was kept in place by velcro bands. Physiotherapists were able to make all adjustments and train the patient 1-2 hours a day. The training started 2-4 weeks after amputation and lasted for 1-4 weeks. Healing problems due to training did not occur in well healed stumps where training started 3 weeks or more after amputation. Influence on maturing of stump, hospital stay and walking ability three months after amputation was not found, but we had an impression of a psychological advantage and a simplified gait training at change to definite prosthesis after early training with the total contact, temporary limb.

INTRODUCTION

Immediate postsurgical limb fitting for amputees was introduced by Berlemont (1961), Weiss (1969) and others in the middle of the sixties but it was soon found that ischemic elderly tolerated this much less than traumatic cases (Cohen et al., 1974) and that postoperative plaster shell gave better healing than immediate walking with a prosthesis (Mooney, 1971). Early fitting replaced immediate fitting in most centers. The number of below-knee amputations has increased much (Liedberg and Persson, 1982). Simultaneously traumatic and tumorous conditions are less often treated by amputation. Among these predominantly elderly patients early fitting has had a tendency to be postponed 1-2 months to allow a safe healing of the wounds and simultaneously to reduce the need for repeated changes of the socket due to postoperative muscular atrophy and resorption of oedema.

Therefore, simple temporary limbs for the first training are wanted. When used, the casting for an individual socket can be postponed some weeks until the stump is more mature. Different types of limbs have been designed to meet this need. Some have been made with high ischial support to unload the stump during healing (Devas, 1977; Hierton, 1980). Some have been utilizing airbags (Little, 1971; Kerstein, 1974; Redhead et al., 1978). Others have used an individually casted temporary prosthesis of different materials (Ruder et al., 1977; Winkler and Fitzlaff, 1980). The ready-made temporary prosthesis tested in this study is with a total contact socket, which is molded on the stump when put on (Henriksen et al. 1977), but in spite of this it is a one-size and ready-made type of aid which does not need any participation from the orthopaedic technical department.

In a preliminary prospective but unrandomized series of 30 patients with a below-knee amputation it had been clinically tested and adjusted to be put into use at the department of orthopaedic surgery in Lund, Sweden. This study was made to study how it was tolerated by the patients and how it influenced on healing and on rehabilitation.

MATERIAL AND METHOD

In this prospective randomized series patients amputated of ischemic disease at below-knee level during 1978 through the first half of 1980 were distributed according to birth. All amputations except one was performed with the sagittal incision described by Persson (1974). Of these 169 patients 79 had an even birthday and were randomized to use a special prosthesis called the Tulip limb. (Tulpanprotes, LIC, Solna, Sweden). Ischial weight bearing temporary prosthesis was used only if secondary healing of long duration occurred.

From the 169 patients 74 were excluded. During the first months of 1980 patients randomized to the non-Tulip group were allowed to use a Tulip limb erroneously. The physiotherapists during the last months of study could not resist the wish of these patients to walk with the limb. These seven patients showed no differences compared to the rest of the non-Tulip group and were excluded. Patients who died within 3 months from amputation or were re-amputated were also excluded from the study. Finally a number of patients were lost from reexamination because they lived at homes or nursing homes far away from the hospital (Table 1). In this study all were ischemic amputees.

Table 1. Exclusion of patients from study

Cause of exclusion	Tulip	Non Tulip
Dead	16	17
Reamputated	8	9
Unaccessible	8	9
Not following randomization	0	7

The distribution according to age, sex, side and number of bilateral cases was studied (Table 2).

Table 2. Distribution of patients in test

Sex and Side	Tulip	Non Tulip
Male/Female	30/17	21/27
Left/Right	28/19	25/23
Uni/Bilat	38/9	38/10
Total	47	48

Among ischemic amputees there is a great proportion of elderly with other symptoms of cardiovascular disease. A screening of somatic and mental conditions on clinical grounds was therefore done during the first week after amputation and before the plaster of Paris was opened. In one patient the somatic condition was not available. In this way a classification of the rehabilitation potential in the two groups was done (Table 3). The use of Tulip-limb is shown in Table 4.

Table 3. Somatic and mental conditions for prosthetic rehabilitation

Condition	Tulip	Non Tulip
Good somatic	25	21
Questionable somatic	16	15
Bad somatic	6	11
Good mental	37	35
Questionable mental	9	7
Bad mental	1	6

Table 4. Primary randomization and final use of Tulip limb

Use of limb	Tulip	Non Tulip
Used Tulip limb	35	0
Used other limb	3	9
Used no temp. limb	9	39
Total	47	48

The temporary prosthesis with total contact used in this study was of an endoskeletal type where the tube length was adjustable within a length of 12 cm. The foot could be rotated inwards and outwards but not translated antero-posteriorly or mediolaterally. The foot had a single axis moving ankle and was a one-size foot made to fit both left and right side. The socket reached 10-20 cm above the knee joint line and was made up by four separate sides like blades of a tulip flower. Hereby the width in all directions could be adjusted. On the anterior blade a patellar tendon support was placed to releave pressure from patella (Fig. 1). Total contact

was created by use of a thin plastic pillow with small plastic pellets and several parallel connected sections. This pillow was wrapped around the stump and the air evacuated making it rigid (Figs. 2 and 3). The stump with pillow was then introduced into the Tulip socket and kept in place by velcro bands around it. During this application some adjustments for creating a correct alignment was possible. At walking about 15 degrees of movement in the knee was allowed within the upper part of the socket. Normally the patients used



Fig. 1. The ready-made temporary prosthesis used, with adjustable length and universal foot, with velcro bands to control width and patellar tendon support.



Fig. 2. The vacuum pillow to be wrapped around the stump, fixed with velcro bands and made rigid by evacuation of air.



Fig. 3. The total contact at end of stump achieved by folding the flaps before evacuation of air.

this limb for 30-60 minutes in the morning and in the afternoon. Both application, instruction, training and observation of the effects were performed by the physiotherapists. The stump healing was classified as primary or with a minor necrosis (less than 0.5 cm) or larger (above 0.5 cm) leading to a secondary healing process. Secondary breakdown of a wound was also noted when occurring.

The volumes of the stumps were followed postoperatively by circumferential tape measurements distally and proximally at the basis of the stump at 2, 4, 6 and 12 weeks.

RESULTS

The use of prosthesis began normally three weeks after surgery (Fig. 4) and the duration of training was 2-3 weeks (Fig. 5).

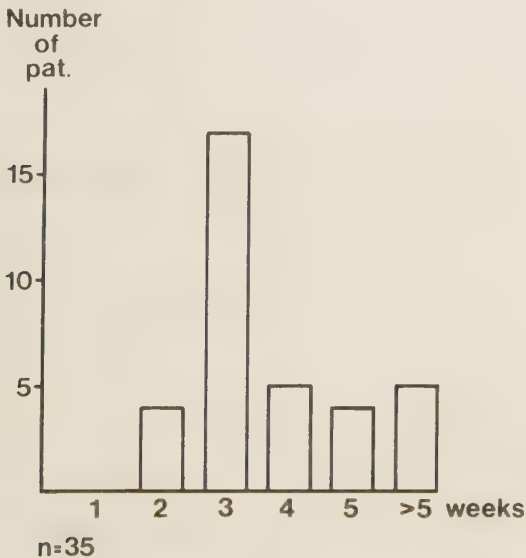


Fig. 4. Time in weeks from amputation to start of training with Tulip limb.

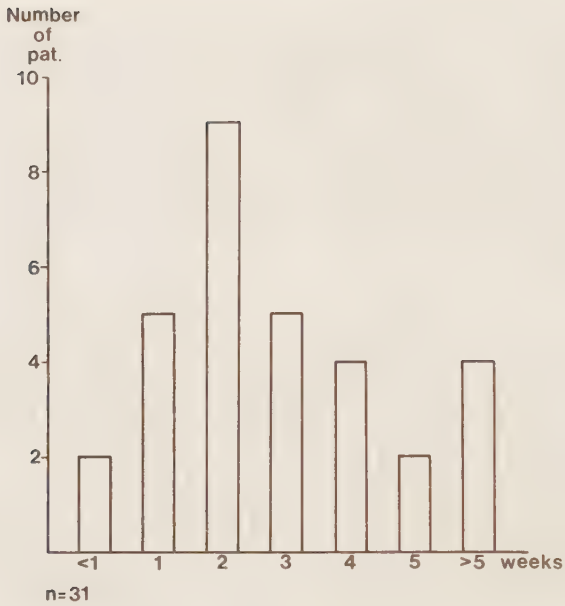


Fig. 5. Duration in weeks of training with Tulip limb.

Secondary ulceration on the healed stump occurred in both groups (Table 5). Only one had used the Tulip limb before the secondary ulceration occurred, and the patient began his training only 15 days after the amputation.

Table 5. Wound healing and secondary ulceration

Healing	Tulip	Non-Tulip
Primarily healed (6 w)	25	21
Secondarily healed	10	12
Healed with secondary ulceration	12	15
Total	47	48

Seven patients started the Tulip training despite not being healed. On two occasions reamputations were needed (training began 19 and 20 days after amputation), in one the wound diastases increased before the secondary ulceration was healed and in four cases the secondary ulceration healed with careful continuous training with prosthesis.

The maturiness of the stumps was observed by clinical judgement of resorption of oedema and muscular atrophy. The number of days between amputation and plaster casting for making a socket was recorded (Table 6). About three of four patients in both groups were casted for making a socket to a definite limb 1-6 months after amputation and without statistical difference between the groups. Normally the definite prosthesis was made two months after amputation. The delivery of this definite prosthesis normally was 14 days later without difference between the groups.

Table 6. Time in days from amputation to casting for making socket for definite prosthesis

Number and time	Tulip	Non-Tulip
Number of patients	47	48
Number casted	36	35
Mean time	64	63
Median time	45	54
Range	31-181	25-206
SD	41	35

The walking ability three months after amputation was studied by the number of supports (Table 7). Only 10 patients had no or one support and there was no difference between the groups.

Table 7. Walking status three months after amputation.
Number of patients using canes, tripods and
wheelchair.

Walking aid	Tulip	Non Tulip
No support	2	1
One support	4	3
Two supports	23	22
Wheel chair	18	22
Total	47	48

To what extent the maturing of stumps was stimulated or disturbed by the use of the Tulip limb was studied by the shrinking rate measured by proximal and distal circumference of stump and length between joint line and end. Using these measurements a cut cone was calculated as an arbitrary volume of stump. There was a decrease in volume of about 7 % from first measurement at two weeks to third measurement at twelve weeks, but there was no difference between the groups.

The mean stay in hospital after amputation was 46 days in Tulip and non-Tulip groups with median values 39 and 36 days, respectively, and standard deviation of 28 and 41 days.

DISCUSSION

The technique of molding a vacuum pillow socket directly on a stump as in this study is unique. It is less bulky than the air-bags (Little, 1970; Kertein, 1974; Redhead et al., 1978) and easier to adjust to the patient than those with ischial support (Devas, 1977; Hierton, 1980). After the international presentation of this limb at the International Society for

Prosthetics and Orthotics in New York by one of the authors 1977, this clinical test has been going on to evaluate its effects on the rehabilitation. Normally it is said that a stump that has healed will remain healed but in this series 27 patients of 95 were found to get secondary breakdown of the wound after being healed. Of these 27 only one had started to use the Tulip limb prior to the secondary breakdown and this patient started to use it 15 days after amputation. The secondary breakdown did not occur until the fifth week after amputation and the small breakdown healed despite continuous use of the Tulip limb. Two of the reamputated patients had used the Tulip limb despite they were not healed, starting 19 and 20 days after amputation and they developed accelerating stump problems necessitating reamputation.

We have observed a small number of reddening and stretching of suture line when starting training in the second and third week and because of this the training was postponed till 21 days after amputation and after the stitches had been removed.

The number of walking supports at three months after amputation was the same in the Tulip as in the control group, but the physiotherapists training the patients had a general impression that the early use of the training aid simplified later gait training. The patients could easier change from a three-point gait using two crutches and one leg to a four-point gait using alternating weight-bearing on each limb with the opposite support. The use of the Tulip limb therefore was believed to be an advantage in the training. More so it was considered to be a special advantage in cases with debatable walking possibilities due to debilitated general condition. In such cases the physiotherapist could use the Tulip limb for testing the walking ability and training the patient a few days before a decision was

made whether to prescribe permanent limb or not. Especially now when many patients are above 80 (Liedberg and Persson, 1983) about a third will never be active walkers. Almost half of all in this study had a wheelchair for help at three months.

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VI

SOCIOMEDICAL HISTORY AND PREDICTION OF REHABILITATION FOLLOWING AMPUTATION FOR ARTERIAL OCCLUSIVE DISEASE

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ABSTRACT. The increased incidence of amputation for arterial occlusive disease in the elderly increases the importance of evaluating the social and medical history in relation to results of rehabilitation. A consecutive series of 182 patients was studied by a rehabilitation team; interest focused on housing and co-living from one year before to one year after amputation. One year pre-operatively 118 were living at home and 57 could return to their own homes. The ability to return home was determined by age, general health, whether the patients lived alone and amputation level but not by bilaterality or secondary healing. Reamputation increased the mean hospital time from 42 to 81 days but did not reduce the chances of returning home. For purposes of planning for rehabilitation, general health was classified as being good in 2/3 of cases. A history of hypertension, myocardial infarction or stroke was found in $\frac{1}{2}$ of all patients. During the previous 5 years 155 had been treated as inpatients for vascular or diabetic complications. Fifty-nine were diabetics and, of these, 17 for 5 years or less. The primary amputation was below knee in 84% but 10% were reamputated to a higher level. Reamputation rate was higher following vascular surgery but not in patients with diabetes. Two third of the below amputees were fitted with prostheses. The proportion able to bath or shower without help decreased much. Prediction figures for returning home were calculated to facilitate planning. The healthy below knee amputee co-living has a probability of 0.9 of returning home.

INTRODUCTION

The number of major amputations in elderly patients due to arterial occlusive disease is continuously increasing (7,8,14, 15). Sometimes it is a waste of effort to try to fit the elderly with a prosthesis (5). Although the mortality in this age group is high and referral to chronic care facilities is common, efforts should always be aimed at making these patients ambulatory and as independent as possible, as well as returning them to their former places of living. A consecutive series of such patients was followed medically and socially to evaluate the overall results of rehabilitation and to determine possible prognostic factors.

MATERIAL AND METHOD

From July 1978 through March 1981 amputees living in Malmöhus county were followed by a rehabilitation team. This team consisted of an orthopedic surgeon, a physiotherapist, an occupational therapist, a social worker and a team secretary. Data were assembled concerning age, sex, marital status, occupation, housing, assistance from the community, general health, hypertension, myocardial infarction, stroke, side, earlier hospitalization for vascular disease, vascular surgery, time of the appearance of necrosis, type of gangrene, diagnosis and immediate reason for amputation, date and level of amputation, bilaterality, day of casting and delivery of definite prosthesis and, finally length of stay at the hospital. Arterial occlusive disease was separated into acute or chronic depending upon if onset of symptoms occurred suddenly, as on a particular day. If amputated within a few weeks it was classified as acute.

All below knee amputations except one were performed using the sagittal technique (17). The above knee amputations were performed with conventional flaps and myoplasty or myodesis. The below knee amputations were post-operatively protected by a rigid dressing of plaster of Paris for 14 days, the sutures were removed at 21 days. Bensylpenicillin and Phenoximethylpenicillin were given routinely during the first week except in a few cases when other antibiotics were used following the results of culture.

A total number of 222 amputations above the ankle had been performed during the observation time, but 9 patients who lived outside the county, and two who moved away from the area were not followed. Thus 211 lower limb amputations in 182 patients were followed. Ninety-two were women and 90 men. The mean age of all patients was 77 years (range 46-98); in men it was 75 (range 46-92) and in women 79 (range 47-98). Fourteen of the men and 7 of the women were below 65 years of age. Of all amputations 178 were primary below knee in 153 patients, 4 were primary through knee in 4 patients and 29 primary above knee in 28 patients. During the study period 29 were bilaterally amputated and 20 had been previously amputated on the contralateral side, thus leaving 133 patients with unilateral amputation.

The prognostic factors for different levels of rehabilitation were analysed using χ^2 probability tests. The housing levels used were: patient's own home, serviced homes and hospitals.

RESULTS

Social history

At referral for first amputation, out of 182 patients 22 were unmarried, 78 married, 68 widowed and 7 divorced. There were no data in 9. In all, 72 lived together with someone (co-living). Retired were 143, and 22 had been retired early or were unable to work during the previous 5 years. Data were missing in 12 cases. During the year before amputation about 39/118 had help from the community in the household. One year after amputation 25/56 at home had such help.

The situation one year before amputation was chosen as the base for evaluation of social circumstances as vascular surgery and other treatment in some cases had required some months. One year before first amputation 118/182 patients lived at home.

Medical history

Among the 182 patients 45 were under treatment for hypertension, 35 had had myocardial infarction and 39 had had stroke (Table I). There were 62 patients with one of the mentioned conditions while 26 had combinations of more than one factor without difference between diabetics and non-diabetics. During the 5 years before the amputation 155/182 patients had been treated as in-patients for vascular symptoms or diabetic complications with a mean hospital stay of 63 days.

The mean time from first consultation for vascular problems to amputation was 21 months (range 0-291). The mean time from onset of gangrene was 8 months (range 0-94). In 140 of the amputated legs consultation for possible vascular surgery had been made. Among 211 amputations 100 legs had an infected ulcer or

Table I. Diagnoses of vascular diseases among amputees with and without diabetes. N = 182

Diagnoses	Diabetics	Non-diabetics
Hypertonia	18	27
Cardiac infarction	13	22
Stroke	14	24
None	14	50
Total	59	123

necrosis, 82 had a dry necrosis and 20 had intact skin. Data were missing in 9. Among all 211 amputations the surgeon had considered immediate surgery indicated in 22 legs, subacute in 100 and elective surgery in 81. Data were missing in 8. The immediate reason for amputation was assessed and when more than one was present the most relevant factor was recorded (17). In above knee amputations septicemia was more common than among below knee amputations (χ^2 $p < 0.001$) (Table II).

Table II. Immediate reason for amputation. N = 211

Reason	Above knee	Through knee	Below knee
Septicemia or toxaemia	11	-	20
Intractable pain	15	3	120
Functional advantage	1	1	24
Hygienic advantage	1	-	6
Missing data	1	-	8
Total	29	4	178

Among the 182 patients the cause of amputation in 59 was diabetes, of whom 29 were insulin-dependent, 20 were treated by oral drugs and 8 required only dietary treatment. The mean time from detection of diabetes to amputation was 13 years and only 17 had had a diagnosis of diabetes for less than 5 years.

Among the 123 amputations in non-diabetics, 37 were following an acute onset of symptoms suggesting thrombosis or embolism (Table III).

Table III. Types of arterial occlusive disease (AOD) at amputation. N = 211

Diagnosis	Number
AOD without diabetes	139
Chronic	102
Acute	37
AOD with diabetes	72
Total	211

With regard to wound healing, of 178 below knee amputations 6 had been surgically revised at below knee level, one reamputated through knee and 20 reamputated to above the knee. One of the 4 amputated through the knee was reamputated. Of 29 above knee amputations 3 had been revised (Table IV). Out of 17 with intact skin 5 were reamputated, out of 63 with dry gangrene 10, out of 89 with infected ulcer 5, out of 9 without assessed skin condition one ($p=0.07$). The impression of vascularization at the below knee amputation in 150 occasions correlated with reamputation rate ($p<0.001$). Reamputations in cases with sufficient vascularization were only 3/72, with border line 6/53 and with poor vascularization, 9/25. Altogether, vascular surgery before amputation was followed by a high frequency of re-

Table IV. Primary and final level of amputation.

Level	Total	Below knee	Through knee	Above knee	Proportion below knee
Primary	211	178	4	29	0.84
Final	211	157	4	50	0.74

amputations, in 16/59 compared to 5/119 without ($p < 0.001$). Out of the 16 who were reamputated after vascular surgery 9 were after embolectomy and 6 after more than one vascular operation. The reamputation rate was 6/67 in diabetic and 15/111 among non-diabetic.

Rehabilitation

The mean hospital stay was 45 (median 35) days. On 39 occasions an additional hospitalization for prosthetic training was required with a mean time of 20 days. In all 68 patients of 182 died within a year from first amputation. The rehabilitation after an amputation differed according to the housing situation one year before amputation (Tables V and VI). In 104 patients living at home one year before amputation 120 below knee am-

Table V. Housing before and after amputation. N = 182

Housing	One year before amputation	Immediately before amputation	Referred after amputation	One year after amputation
At home	118	44	45	57
At serviced home	38	30	22	25
At hospital	23	106	87	31
Dead	-	-	28	68
Missing data	3	2	-	1
Total	182	182	182	182

Table VI. Rehabilitation after first below knee amputation in series and housing one year before. N = 153

Housing	One year before	Mean age	Mean hospitalization time in days	Dead within 3 months	Dead within one year	At home at one year	At serviced home at one year
At home	104	73	52	12	23	53	16
At serviced home	30	86	51	10	17	-	7
At hospital	17	80	17	4	5	2	-
Missing data	2	-	-	-	-	-	-
Total	153	76	48	26	45	55	23

putation were performed of which 106 were followed to assessment of healing. The mean age was the same in the groups of primary and secondary healed and among the reamputated. Mean hospital time with primary healing was 42 days, with secondary 71 and with reamputation 81 days, but returning home was only slightly influenced (Fig. 1).

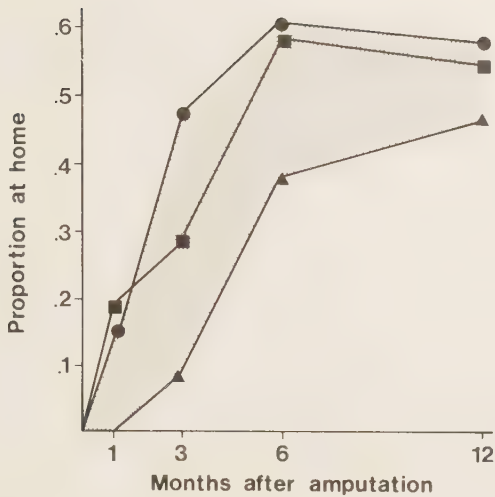


Fig. 1. Proportion of patients returning home after below knee amputation compared to wound healing. The shaded area describes additional hospitalization due to healing complications. ● Primary healed = healed within 6 weeks. ■ Secondary healed = healed at same level also including revision. ▲ Reamputated from below knee to a higher level.

Prosthesis was fitted to 100 of the 157 final below knee amputations and to 8 of the 21 reamputated, in none of the 4 primary through knee amputated and in only 4 of the 29 primary above knee amputated. The time from amputation to delivery among below knee amputees was most often 6 to 7 weeks (Fig. 2). The median time from casting for a prosthesis to delivery was 14 days. At 76 visits to amputees in their own or serviced homes one year after amputation patients and relatives were asked about the actual use of prosthesis. Sixty-two used it almost daily and for walking, whereas 14 did not. At the same visit the prosthetic fitting was evaluated and 37 fitted well while 34 needed adjustment of which 10 needed it semi-acutely. In 5 cases evaluation could not be made.

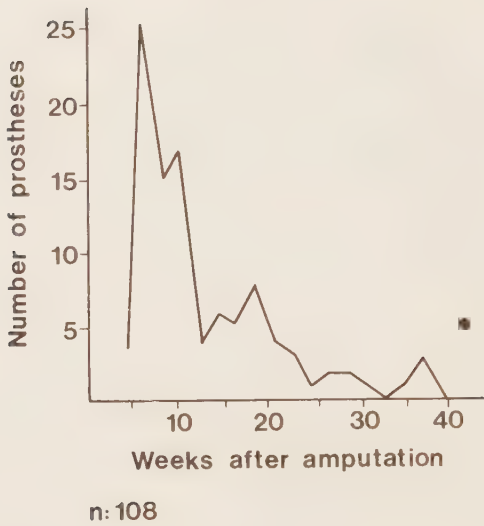


Fig. 2. Time in weeks from amputation to delivery of definite prostheses. Only 5 received their prostheses after 39 weeks after amputation.

Activity of daily living (ADL) pre-operatively at 3 months before amputation was assessed retrospectively. Among 124 patients amputated at below knee level and who had been living at home or at serviced homes one year before amputation 81 were alive at 6 months and 68 could be evaluated concerning pre-operative ADL. (Table VII).

The age was noted and an evaluation was made of general somatic condition and living situation in 108/120 amputees who had been living at home one year before amputation. Age influenced the likelihood of returning home. Of those under the age of 80, 51/84 returned home compared to 8/24 of those 80 years or more ($p < 0.05$). The generally healthy returned more often home (44/57) than those not healthy (15/51) ($p < 0.001$). The amputees living together with someone returned more often (42/60) than those living alone (17/48) ($p < 0.001$) (Table VIII).

Table VII. Proportion managing ADL without help after below knee amputation in patients who lived in own or serviced home one year before amputation. N = 68

Activity	Three months before	Six months after
Pick up things	0.66	0.64 (NS)
Walk indoor	0.87	0.81 (NS)
Use taxi or train	0.53	0.41 (NS)
Raise from chair	0.94	0.85 (NS)
Walk to shop	0.58	0.36 (NS)
Walk in stairs	0.69	0.47 (NS)
Bath or shower	0.81	0.46 (P < 0.001)
Raise after fall	0.73	0.31 (p < 0.001)

Table VIII. Proportion returning home within one year after below knee amputation. All had been at home one year before, living alone or co-living. N = 108

Health and living	Proportion at home	Dead
Healthy, co-living	0.9 (29/33)	3
Healthy, alone	0.6 (15/24)	3
Not healthy, co-living	0.5 (13/27)	8
Not healthy, alone	0.1 (2/24)	6
Total	0.6 (59/108)	20

Among patients who lived at home before amputation the rate of returning was about the same in unilateral as in bilateral below knee amputees (Table IX). Indication for amputation did not predict the patients probability of returning home (Table X). The amputation level was important (Table XI).

Table IX. Comparison between unilateral and bilateral below knee amputees concerning housing one year after amputation.
All had been at home one year before.

Amputation	At home	At serviced home	At hospital	Dead	Total
Unilateral	39	15	7	15	76
Bilateral	14	1	5	8	28
Total	53	16	12	23	104

Table X. Rehabilitation after first below knee amputation according to indication.

Indication	Total No.	Uni- lateral	Mean age	Reamputa- tions	Mortality within 3 months	At home one year before amp.	At home one year after amp.
AOD without diabetes							
Chronic	75	63	76	7	12	50	28
Acute	22	22	79	7	6	12	3
AOD with diabetes	54	47	76	5	7	40	24
Missing data	2	-	-	-	1	2	-
Total	153	134	76	19	26	104	55

Table XI. The influence of amputation level on ability to return home.

Final level	Amputations No.	Patients at home one year before	Patients at home one year after
Below knee	157	91	49
Reamputated from below knee to higher level	21	13	6
Primary above knee	29	13	2

DISCUSSION

It is of importance to evaluate the likelihood of an amputee's returning home if he came from his own home. The probability of amputees coming from serviced homes or a hospital to return to their own homes is, of course, minimal (Table XI). It is important in the evaluation of rehabilitation to have easily understandable and clearly defined groups (2). It might seem unnecessary to investigate more than health and living situation as these two factors predict the success or failure in 90%. Still there are other aspects of the rehabilitation of the elderly amputee with arterial occlusive disease. The most important is the avoiding of further amputations. Meticulous care of the diabetic foot reduces the need for amputation (12). The fraction of diabetics in this study was 0.37. The cessation of smoking reduces the risk of needing an amputation (13).

The restrictive indications for amputation used here i.e. toxaemia, intractable pain or functional advantage will reduce the danger of a premature decision to amputate.

When amputation is needed it should be made as distally as possible so as to preserve function. In this series the propor-

tion of primary below knee level amputations was 0.84 and of final below knee amputations was 0.74. The choice of amputation level in this series was based primarily on clinical grounds. When performed as distally as possible according to skin perfusion blood pressure, others have reported the proportion of primary below knee level amputations was only 0.45 and of final such amputations 0.36 (9,16). Some authors have advocated the increased use of through knee amputation if stump viability would be uncertain with a below knee amputation (10).

The proportion of reamputation among patients without vascular surgery was 0.04 compared to 0.27 after all forms of vascular surgery. Burgess (3) did not find increased problems after reconstructive vascular surgery. It is suggested that in patients without vascular surgery it is better at least to try a below knee level and, if the surgeon concludes that the likelihood of satisfactory healing is low, to continue in the same seance to make a through or above knee amputation. Devas (6) considered independence very important. The consideration of social rehabilitation is central in the rehabilitation of the amputee even in a wheel chair.

It has been reported that 2/3 of below knee amputees can be fitted with a prosthesis as compared to 1/3 after above knee amputation (4,19). In this series the proportion fitted after below knee amputation was the same but the above knee amputees had a lower level of prosthetic rehabilitation, probably because the proportion of above knee cases were low and in poor health. Davis (5) found a prosthesis rejection rate of 0.49 two years after fitting. In this series the rejection one year after a below knee amputation in patients living in their own or serviced homes was 0.18.

Allgulander and Mattsson (1) concluded that a nursing home or geriatric ward is best suited to rehabilitating amputees. In our series the highest proportion of patients (0.38) were referred directly to their own homes after amputation and only a few

additional patients (0.09) returned home after rehabilitation at other facilities.

Stirneman et al. (18) showed that below knee amputees could manage ADL as well as they could pre-operatively. The impairment of ADL is fairly small in healthy elderly amputees as they have had a decreased demand for activity in and outdoors even before amputation. Kohn and Gordon (11) found that bathing was important for independence. In this study the proportion able to bath or shower without help decreased from 0.81 to 0.46 from 3 months before amputation to 6 months after amputation. This could be a result of loss of ability to rise after falling (from 0.73 to 0.31 6 months after amputation).

When planning for rehabilitation it is important to assess amputation level and socio-medical history to be able to predict the probability of returning home. A healthy co-living below knee amputee, should return home but it might be better to plan for long term care rehabilitation on a geriatric ward for patients with a number of negative factors.

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